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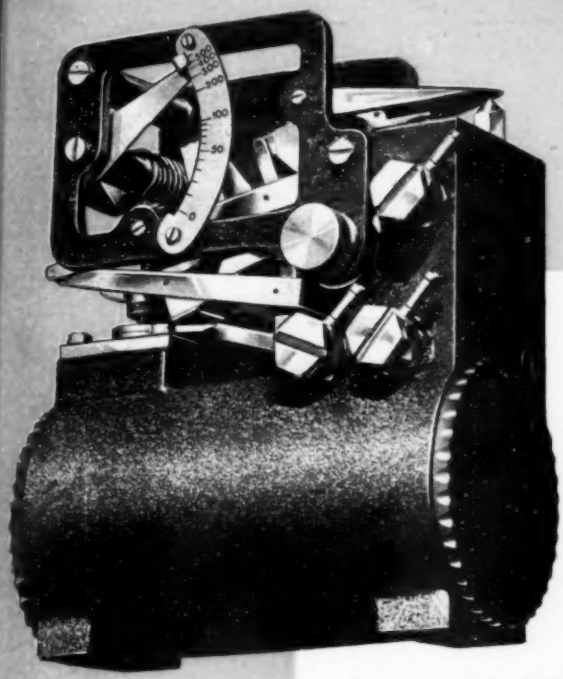

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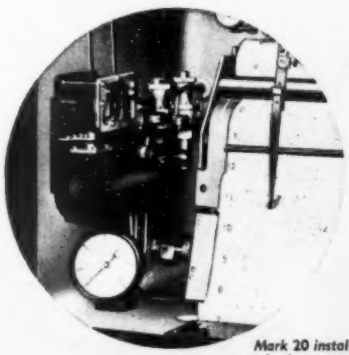

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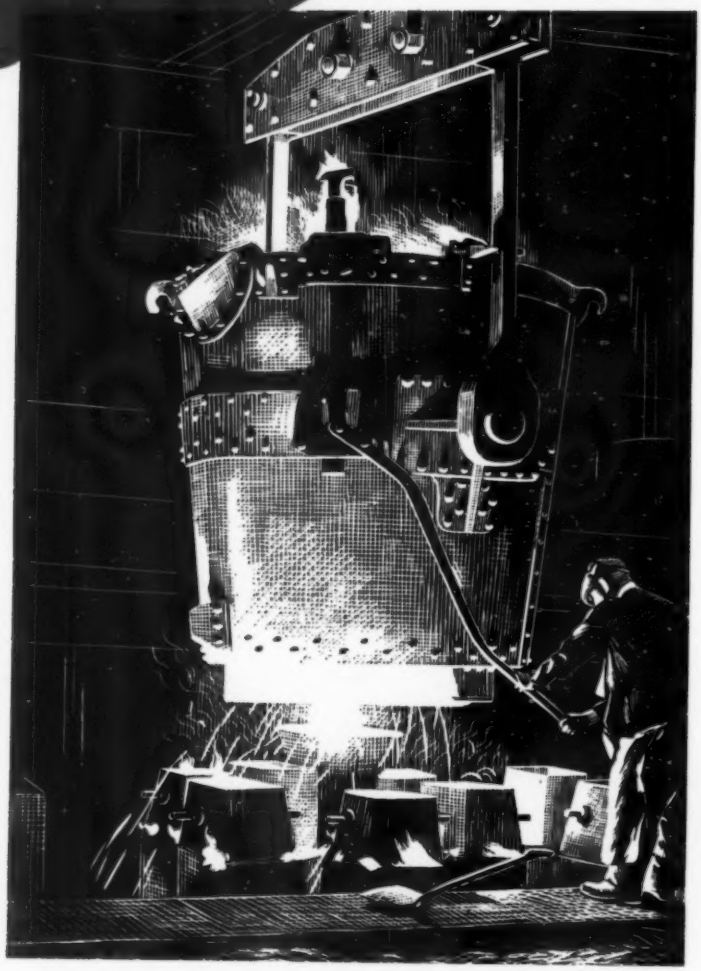

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THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER"

SEPTEMBER, 1952 Vol. XLVI No. 275

Better Mousetraps

DURING the last few years, there have been many references to "indirect exports" and to the way in which they have helped in the struggle to bridge the dollar gap. Much less has been heard, however, of what may be termed the "indirect war losses" sustained by this country, which have had an adverse effect on the balance of payments. The losses in manpower and bomb damage are self-evident, and there is fairly widespread appreciation among thinking people that our sacrifice of overseas investments, in order to continue the struggle against the Axis Powers, has meant that raw materials and foodstuffs can now only be purchased by the sweat of our brows, but the indirect losses we have suffered are not so easily recognised, nor are their economic consequences so widely understood. As an example, we may take the electricity supply industry, in which age took more toll of generating plant during the war than did enemy bombers. During that period, the manufacturing capacity of the large electrical engineering factories was geared to the war effort and, in consequence, only absolutely essential generating plant was manufactured. The inevitable result was that the end of the war found our power stations with an unusually high percentage of generators which had outlived the normally accepted front-line machine life, so that the industry was faced with the task of replacing a lot of obsolescent sets simultaneously with the provision of new plant to meet the increased demand for electricity. In consequence, industry as a whole has been hindered in its efforts to increase productivity by the power cuts which have been responsible for a reduction—temporarily at least—in the machinery available, rather than the increase recommended in most of the reports of the productivity teams which have visited the United States.

In the same way, the aircraft industry concentrated its attention on the production of fighters and bombers, leaving transport planes to others. This again affected us adversely and it seemed, just after the war, that the industry which had designed and built the Spitfire, Hurricane and Lancaster, which had contributed so much to ultimate victory, would be unable to meet Britain's requirements for civil planes, and British airlines were compelled by force of circumstances to go to the United States for the machines with which to run their services. However, the industry faced up to the situation and, taking advantage of the lead established by this country in the jet engine field, proceeded to develop a number of civil and military aircraft using either pure jet engines or gas-turbine driven propellor engines. This work is now coming to fruition and, in spite of the tragic mishap to the de Havilland 110, the Society of British Aircraft Constructors certainly put on at Farnborough, at the beginning of this month, a show worthy of the highest traditions of the industry. Dr. Heinkel, the German designer estimates that the British aircraft industry is at least three or four years ahead of that of any other country.

The supersonic flights and the new delta-wing fighters and bombers naturally attracted a good deal of attention, as did the Canberra, fresh from its "across the Atlantic and back in time for tea" triumph, but the plane which has done most to uphold the truth of Emerson's dictum —'If a man write a better book, preach a better sermon or make a better mousetrap than his neighbour, though he build his house in the woods, the world will make a beaten path to his door"—is the Comet jet airliner. Now, instead of British airlines going to the United States for their planes, at least one U.S. airline would like to use the Comet on its services, so that there is a possibility of aeroplanes assuming the role of dollar earners instead of calling for dollar expenditure. There are one or two difficulties in the way of this becoming an established fact, but they do nothing to negative this confirmation of the theory that quality sells.

The standard of living enjoyed by the workers in this country and the size of the home market make it difficult for British industries to compete with Japan, on the one hand, and the United States, on the other, in the mass production of consumer goods. In former days, we built up our industrial and commercial supremacy by pioneering methods—we were first in the field. That advantage is no longer ours: in fact, in some cases it is now a disadvantage, as those who have followed are better equipped than we are. There are still fresh fields to conquer, but the struggle is now much more intense and progress so rapid that a vital factor in the success of any new development is the speed at which it can be turned into a practical proposition and produced in reasonable quantities.

Whilst industrial success may be initiated by the development of new processes and products, it is maintained chiefly by the quality of those products. It is, therefore, disturbing to read in a letter to the *Manchester Guardian* of an Englishman now working in Mexico who is "becoming very embarrassed at being English," the reason being that in a number of mills he has to visit he gets nothing but complaints about the poorness of British machines. He points out that one of our selling points used to be quality, but adds that he is appalled at the sort of machines being turned out now, with all the little final details wrong or shoddy or missing. It may be argued that these are isolated examples and that the main bulk of our exports are of reasonable quality. It is, however, by no means certain that such is the case, and even if it is, it should be remembered that even a small proportion of shoddy goods is extremely effective in gaining a reputation for poor quality.

We have in the past built up a tremendous goodwill because of the quality of our manufactures, and any who do anything to diminish that goodwill—whether by poor quality workmanship, slackness in supervision, or a willingness to allow shoddy goods to be made to increase profit—are guilty of doing a great disservice to their fellow-countrymen.

Final Productivity Report

THE Anglo–American Council on Productivity had been in existence over 3½ years when the U.S. and U.K. Sections held their fifth and last joint session in May of this year. At that time a general assessment of its work was made available to the public. Fuller details of its operations and methods, and the results achieved, are set out in The Final Report* recently.

It is believed that one of the most important benefits of the Council's work lies in the improvement of the climate of opinion about productivity, but a change of such a nature is incapable of short-term accomplishment, and it is made clear that the full harvest of the programme is still to be gathered. Work will therefore continue to be pressed forward by the U.K. Section of the Council until it can readily be absorbed into that of the British Productivity Council, shortly to be established. The formation of a continuing organisation in America is also being considered in order to maintain liaison with the British Productivity Council. The facilities provided for team visits to the United States under the Economic Co-operation Administration Technical Aid Programme will still be open through its successor, the Mutual Security Agency, under somewhat different conditions, and will continue to be handled from the offices of the U.K. Section in London.

The Report gives, in four chapters, a documented review of what has already been accomplished. By way of foreword a tribute is paid by the Chairman of the U.K. Section to the generosity of the American people and the co-operation of the U.S. Government and industry alike, which have helped to turn into reality the vision of Mr. Paul Hoffman and the late Sir Stafford Cripps. Clearly the Council entertains no doubt of the success of the enterprise and of this success it now offers substantial evidence.

Chapter 1 gives a general picture of achievement and an outline of the forthcoming developments touched upon above, whilst Chapter 2, entitled "The Organisation and Meetings of the Council" is largely historical and recapitulates the proceedings of the five committees originally established to study various subjects considered worthy of investigation.

Experience quickly showed the activities of the committee charged with the promotion of plant visits to be the most fruitful. Nevertheless, valuable investigations were carried out on the maintenance of productive plant and power; productivity measurement; standardisation, specialisation and simplification in industrial production; and the spread of economic information.

Chapter 3, "The Work of the Council" sets out details of the step-by-step advance into what had been to a large extent uncharted territory. A list is given of the 66 teams (47 industry and 19 specialist) that have visited the U.S., and a description is given of the machinery for the preparation and publication of team reports, for the dissemination of the teams' findings and for their implementation—necessarily a lengthy process. Special emphasis is laid on the task of dissemination; the real work in fact begins after the reports are published and it is this phase that gives the greatest promise of results still to come.

* Copies of the Report may be obtained from the Anglo–American Council on Productivity at 21, Tothill Street, London, S.W.1, price 3s. 6d. post free.

What has the programme cost? The question is answered in Chapter 4 which includes a summary of the receipts and expenditure of the U.K. Section and of the expenditure of the U.S. Section. The total cost is given as approximately £844,500, of which some £320,400 represented sterling expenditure and £524,100 ($1,467,480) was met by the U.S. Section.

"Of the total U.K. expenses, almost £180,000 were met . . . directly out of a grant-in-aid from the U.K. Treasury and contributions from the British Employer's Confederation, the Federation of British Industries and the Trades Union Congress" (constituent bodies of the A.A.C.P.). This grant-in-aid was charged, with the concurrence of E.C.A., against the counterpart fund, *i.e.*, the sterling receipts in payment for goods supplied under Marshall Aid. No less than £141,000 has also been contributed by British industries directly concerned in sending teams to the U.S. In fact, "the direct contribution of U.K. industry and the U.K. participating organisations together covered more than half the sterling expenses incurred by the programme." An analysis of the sterling costs puts the average per team member at £287, of which £132 came from the grant-in-aid.

Some of the most interesting material in the Report appears in the Appendices. The necessity for careful organisation on both sides of the Atlantic in handling team visits is brought out. The specimen itinerary of one of the teams and the description of the work of the U.S. Section are an indication of the efforts made, there as here, to ensure the maximum benefit being derived by British industry from these visits.

What benefit has, in fact, already been derived? A brief summary (Appendix 2: "Impact of the Reports in Industry") is given of developments in seven British industries which were among the first to send out teams and in which the effect of the reports has had time to make itself felt. "In those industries investigated it has been found impossible to discriminate clearly between action taken as a result of a productivity team's visit and what has happened as part of normal development in the post-war period. It should not, therefore, be assumed that all the developments referred to have taken place as a direct result of the team reports . . . The developments which are taking place are, however, generally in line with the recommendations contained in the reports."

What the reports have done, then, is to direct the attention of industry as a whole, and especially of the medium-sized and smaller firms, to the advantages of adopting new techniques, and to stimulate developments generally. The A.A.C.P. is in process of preparing more comprehensive "follow-up statements" respecting individual industries, and eventually this series is likely to cover all the major industries that sent out teams.

SUNVIC CONTROLS, LTD., the well-known manufacturers of temperature control and measurement equipment, announce that, owing to their extending interests in Europe, they have found it necessary to open a Continental Office. Accordingly, their European Manager, Mr. B. Hveissel, has transferred to Copenhagen where his address is:
Sunvic Controls, Ltd., Continental Office, Skindergade 38, Copenhagen K., Denmark. Telephone: Central 1402.

Recent Applications of High-Frequency Induction Heating in the Forging Industry

By P. D. Jenkins, B.Sc.(Eng.), A.M.I.E.E.
The Electric Furnace Company Limited

The use of high-frequency induction equipment for heating materials prior to forging is increasing. In this article the author outlines the characteristics of the method before describing typical plant for billets, bars for upset forging, and pins for bolt heading.

THE heating of metal by high-frequency power is being used to an increasing extent by a large number of progressive forging manufacturers, as the need at the present time is for increased production, reduction of waste and better working conditions and it is only by the use of high-frequency power in the forge shop that all these can be realised. Some forging manufacturers are finding it increasingly difficult to recruit labour to work in some of their old forge shops due to the poor working conditions—a situation that could be appreciably ameliorated by the installation of the latest type of high-frequency heating plant.

The number of high-frequency heating plants installed in the forging industry in this country is still a small percentage of the total, due largely to the high capital cost of the plant. However, providing the high-frequency plant has been well designed, is thoroughly reliable and is used on long continuous runs, a definite saving of cost over the more conventional forms of heating is achieved.

The main advantages of this form of heating may be summarised as follows :—

(*a*) high output in both tonnage and pieces per hour ;
(*b*) instant starting, without warming up ;
(*c*) cool, quiet and clean working conditions ;
(*d*) small floor space ;
(*e*) uniformity of temperature ;
(*f*) virtual elimination of scale, due to rapid rate of heating ;
(*g*) mechanical handling ;
(*h*) use of semi-skilled labour ; and
(*i*) small maintenance cost.

Characteristics of Method

This method of heating differs from all others in that heat is actually generated in the work-piece itself. If a steel bar or billet is placed within the magnetic field of a coil through which high-frequency currents are flowing, eddy currents will be induced in it. These currents flow in the same plane but in the opposite direction to the coil or primary currents, and heat is produced which is proportional to the square of the current, this being the I^2R law.

There is no actual physical contact between the primary coil and the billet, and the principle is therefore identical with that of an air-cored transformer in which the coil acts as a primary winding and the billet as a secondary winding. The better the coupling between the billet and the coil, the higher will be the efficiency.

The secondary currents do not flow evenly throughout the cross-section of the billet, but tend to concentrate in the outer layers. This is known as the " Skin Effect " and is caused by the currents distributing themselves in such a way that the reactance of their paths is a minimum. The depth of current penetration is dependent on the resistivity and permeability of the metal and the frequency of the supply, but for any one metal at a particular temperature, the depth is inversely proportional to the square root of the frequency. As an example, the depth of current penetration in steel is 0·2 in. (0·5 cm.) at a frequency of 10,000 c/s. and a temperature of over 800° C.

For any particular frequency the efficiency falls off rapidly if the diameter of bar used is reduced beyond a certain value. For example, at 10,000 c/s. it is not commercially practical to heat to forging temperature bars much less than $\frac{3}{8}$–$\frac{1}{2}$ in. in diameter. Similarly, if a high frequency is used on a large diameter bar, heat is only generated at the surface and the inside of the bar is heated up by thermal conduction from the outer surface. This will require a longer heating time and hence will give a lower efficiency, also the rate at which power can be induced in this large bar is limited since, if this is too great, it is possible to overheat the surface of the bar while the inside is still relatively cool.

A conversion efficiency of up to 0·2 kWh. L.F. per lb. of steel heated to about 1,200° C. may be expected. The power requirements for forging are, of course, dependent on the weight of steel to be heated per hour, but they generally have a range from about ten to several hundred kilowatts per heater unit. Motor generator units are the most suitable means of providing this power, and they are available with outputs of up to 1,500 kW. and frequencies of from 500 to 10,000 c/s. This range of frequencies is suitable for heating any size of stock from about $\frac{1}{2}$ to 6 in. diameter or square, which covers most forging requirements.

A fixed frequency is normally used for an induction heater unit and the choice of this frequency is a matter of compromise. Where a variety of sizes have to be heated on the same unit, it is always preferable to select the frequency to suit billets of the smallest cross-sections, as it is possible to heat up the larger billets with the higher frequency, although the heating time will of course be greater.

Most heating applications are concerned with the heating of billets for forging and the end heating of bars or pins for upset forging. Recent applications of induction heating for this type of work are given below.

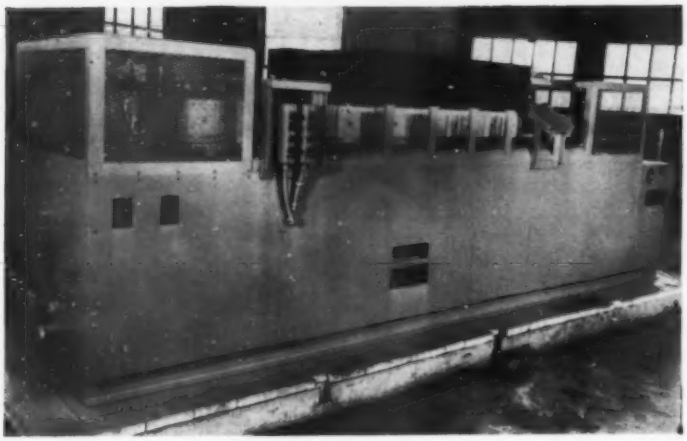


Fig. 1.—Billet heater with in-line channel-type coil and horizontal conveyor.

Billet Heaters

One type of in-line billet heater has recently been installed in the forge shop of a large automobile works in Paris and is used in conjunction with a large power press. It is rated at 300 kW., 1,100 V., 2,200 c/s. and can handle round billets varying from 55–80 mm. (2·17–3·15 in.) in diameter and about 76–254 mm. (3–10 in.) in length. It is capable of an output of up to 1,600 lb./hr. at a temperature of 1,200° C.

Billets are loaded by hand onto a conveyor to the right of the coil, and the loading platform is sufficiently long to allow for several minutes' supply of billets. They are conveyed through an in-line channel-type coil, where they are heated, and finally discharged to the left of the coil by means of a hydraulically-operated discharge mechanism. The operation of this heater is fully automatic, although manual operation may be used if desired.

The conveyor is driven by an electric motor operating through a reduction gear. Its motion is intermittent and its effective speed is controlled by two timers. The speed of the conveyor is about 5 in./sec.; the first timer is set to the time interval corresponding to the travel of the conveyor equal to one billet length, while the sum of the two timer settings gives the time cycle between the ejection of successive billets. For example, suppose an output of 300 billets/hour, or 1 billet every 12 secs., is required, each billet being $4\frac{3}{4}$ in. long. Now allowing $\frac{1}{4}$ in. spacing between billets, the actual billet spacing will be 5 in. Therefore, Timer I is set to 1 sec. and Timer II to 12—1 = 11 secs.

This billet heater is started up from cold with full voltage applied to the empty coil. Cold billets are fed into it and, providing the correct time and power settings have been made, the first billet will emerge at forging temperature. Capacitor contactors are provided to enable the overall power factor of the coil to be kept near unity during the starting up process.

The conveyor mechanism operates in the following manner. With the coil empty, the start button is pressed and the conveyor moves forwards a distance equal to one billet pitch. The two timers are coupled together electrically so that they continually reset each other. This intermittent motion of the conveyor continues until the front billet strikes the trip lever. This stops the conveyor and operates the discharge arm which ejects the hot billet down the discharge chute to the press operator. The conveyor will then reverse and move the end billet back into the coil so that it will be heated up to its correct temperature.

The distance the conveyor reverses is adjustable, and is determined by a reverse travel selector unit, consisting of a cam operating a limit switch and driven off the main conveyor driving shaft. This quick withdrawal of the front billet inside the coil is to overcome the gradual cooling off as it slowly emerges from the end of the coil, and this is, of course, greater the longer the length of the billet.

This billet heater is provided with two different sized channel-type coils to cover the full range of billets specified. Both coils have six electrical turns, each turn being individually cooled, with all the water outlets grouped at one side of the coil. The electrical and water connections are easily made or disconnected so that it is possible to change coils in less than half an hour.

The conveyor consists of a number of trolleys fitted with rollers, on which are clamped the hearth bricks. These are cast from a special refractory which has a low heat conduction, the top surface being faced with a hard-wearing material to reduce the wear caused by the billets. The shape of the top of these hearth bricks

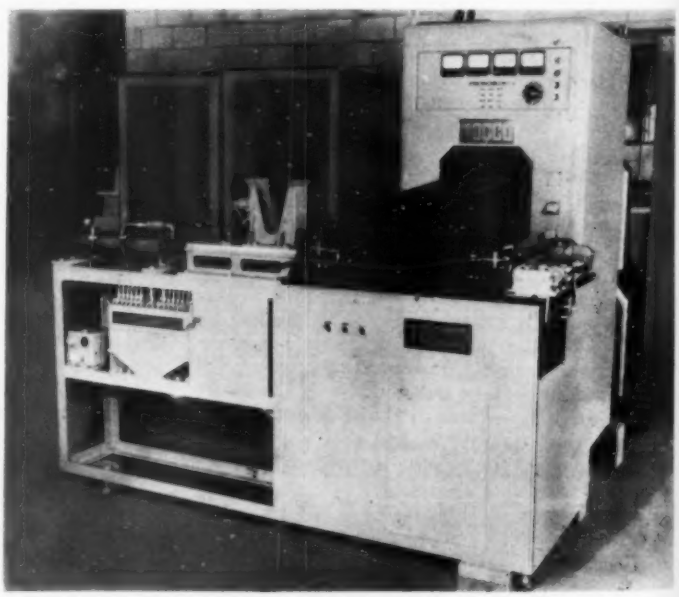


Fig. 2.—Billet heater with straight helical coil and pneumatic ram for pushing billets through it.

is suitable for the full range of billets.

In order to reduce draughts of air through the coil, the outlet end is sealed up with a refractory muff, the inlet has an asbestos string curtain fitted, and an asbestos curtain resting on copper sheets fitted to each of the trolleys is fitted along the bottom of each side of the coil. The muff is automatically raised each time the conveyor moves forward to eject a hot billet. Provision is made for a gas atmosphere to be used inside the coil if desired, to reduce scale formation on the billets. The refractory lining consists of a sillimanite filler with a silicon-ester (ethyl silicate) binder.

A full range of protective devices has been incorporated in this heater. These consist of water-pressure switches in the individual water cooling circuits to guard against failure of water, an over-travel limit switch in case the discharge mechanism fails to operate, and a safety limit switch to guard against premature discharge of a billet.

A small capacitor cubicle is located adjacent to the conveyor unit, in which are housed the water-cooled capacitors, capacitor contactors and knife switches for varying the capacitor bank. Connection to the coil is made with water-cooled bus-bars.

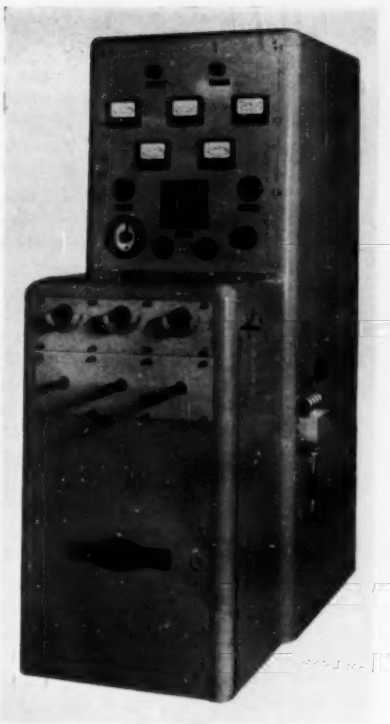


Fig. 3.—Equipment for heating the ends of bars for upset forging.

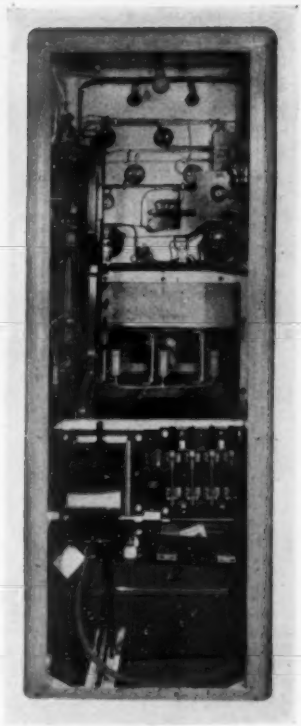


Fig. 4.—The rear view of the heater station shown in Fig. 3.

Fig. 1 shows another type of billet heater using an in-line channel-type coil with a horizontal conveyor. The loading platform can be seen to the left of the coil box, with the discharge chute to the right.

The conveyor is driven continuously by means of an electric motor via a variable-speed gear and gearbox, and a conveyor speed indicator can be seen at the right hand side of the structure. The discharge arm is operated by a hydraulic cylinder, actuated by a solenoid valve which is energised by a limit switch connected to a trip lever which is operated by the end billet.

The capacitors are housed beneath the conveyor, and capacitor switching during starting is accomplished by means of contactors.

Two of these billet heaters are installed in a large forge shop of another automobile works in Paris, and each is connected to a motor generator set rated at 166 kW. 660 V. 2,500 c/s. Four different sized coils are provided to cover a range of billets varying from 30 mm. (1·18 in.) to 74 mm. (2·9 in.) in diameter, at an output of up to 1,000 lb./hr. at a temperature of 1,150° C. This output can be achieved when the largest size of billet is used for any particular coil, but the output is correspondingly reduced when smaller billets are used in the same coil.

In order to keep up the output in such cases, it is necessary to increase the voltage applied to the coil and this is done by connecting an air-cored reactor coil in series with the generator. The coil voltage can then be raised in relation to the generator voltage by adding additional capacitors to the parallel banks, thus causing the coil power factor to lead slightly.

Fig. 2 shows another type of billet heater using a straight helical coil with the billets being pushed through it in line by means of a pneumatic ram. A magazine is incorporated at the ingoing end, and motor-driven rollers for carrying away the hot billets are provided at the outgoing end.

A refractory liner is fitted inside the coil together with water-cooled skid tubes and guide rails. The skid tubes are normally edged with some hard wearing material to reduce the abrasive action of the billets. The speed of throughput of billets is controlled by a timer fitted on the left of the structure, adjacent to the water outlets.

This type of billet heater has certain advantages over the ones previously described, notably quicker heating time, simpler mechanism and more even heating of the billets.

Heating of Bar Ends for Making Upset Forgings

The majority of heating requirements for upsetting are concerned with the heating up of the ends of partially hot bars. The bars start off several feet long and the end few inches are forged and removed during each operation.

The temperature of the bar end after forging is determined by the actual length heated, the amount of heat conducted back along the bar, the length removed and the time taken for forging. The bars eventually become too short to be used and must be replaced by cold ones, which will of course require a much longer heating time than the partially hot bars. This complicates the heating problem and one of the ways of over-

Fig. 5.—Metal cover housing the motor generator set for the equipment shown in Fig. 3.

coming it has been adopted on the heater shown in Fig. 3.

The requirement in this case was to heat $\frac{7}{8}$ in. diameter steel bars over a 10 in. heated length at an output of 200 bars per hour. The end $3\frac{1}{2}$ in. had to be at 1,050° C., and the remaining $6\frac{1}{2}$ in. had to have a temperature gradient tapering down to about 500° C. Two separate forgings were to be produced for each heat, removing a total of about $3\frac{1}{4}$ in. of the bar. It was specified that the length to be heated should be rather long in relation to the length to be forged in order to make the bar slightly plastic where it was gripped by the horizontal clamping jaws of the upsetting machine. The initial length of the bars is about 4 ft. and they can be used down to a length of about 1 ft., being then too short to locate accurately in the guides.

Three coils are provided in the main heater and a total of four bars is continually in use, one in each of the coils and one being forged. Indicating lamps are fitted above each coil and the heating sequence is under the control of a timer. At the end of each time cycle, the timer rings an alarm bell and the operator has then to withdraw the next bar in sequence and replace it with the one which has already been forged. An additional protective timer is fitted so that the heater will shut itself down if the bar is not removed within a specified time of the alarm bell ringing. This is to prevent the possibility of a bar melting inside the coil through an excessive heating time.

Each coil is fitted at its rear end with a spring-loaded stop to locate the position of the bar inside it, and a limit switch, connected to the stop, operates some relays. The action of replacing each hot bar with a partially hot one causes the next lamp in sequence to light, thus indicating which bar should be withdrawn the next time the bell rings.

In order to prevent the generator from becoming overloaded should one or more cold bars be inserted into the coils one after the other, three additional low power pre-heating coils have been provided in a separate cubicle.* These are provided for keeping the ends of unused 4 ft. bars at the same temperature as the bars after forging, i.e. about 700° C.

In this way, no fluctuations of load occur when bars are transferred from the pre-heating to the high power coils. Similarly, due to the low loading of the pre-heating coils, no overloading of the generator takes place when one or more cold bars are inserted into them.

The additional power loss due to the three pre-heating coils is small, the radiation loss being a minimum, since the ends of the bars are completely enclosed. The power loss amounts to under 4 kW., and each coil will raise the temperature of a cold bar to 700° C. in under $4\frac{1}{2}$ mins. Three pre-heating coils are necessary, as it often happens that two or more short bars have to be replaced by long ones in the high power coils in sequence. A further advantage of using pre-heating coils is that the heating time of each bar is reduced.

An output of 200 per hour, i.e. one bar every 18 secs., using three coils, gives a heating time of $3 \times 18 = 54$ secs. Using six coils in sequence gives a heating time of $6 \times 18 = 108$ secs. There would probably be little difference in the total power used, but this longer heating time would certainly increase the scaling of the bars, which is undesirable.

The rating of this installation is 30 kW., 220 V., 8,300 c/s., and a loading of about 24 kW. will give the specified output of 200 bars per hour, equal to 400 forgings per hour.

All the six coils are identical and interchangeable, the three high power ones being connected in parallel, while the three pre-heating ones are connected in series with a tapped reactor coil for adjusting the temperature of pre-heat.

The front view of the heater station is shown in Fig 3. This consists of a small heater station housing the three high power coils bolted to the front of a control/capacitor cubicle. A sequence-indicating lamp is fitted over each coil, and above them can be seen the H.F. meters, electrical controls and a timer. The cooling water outlets are on the right hand side of the cubicle.

*British Patent Application No. 18019/52.

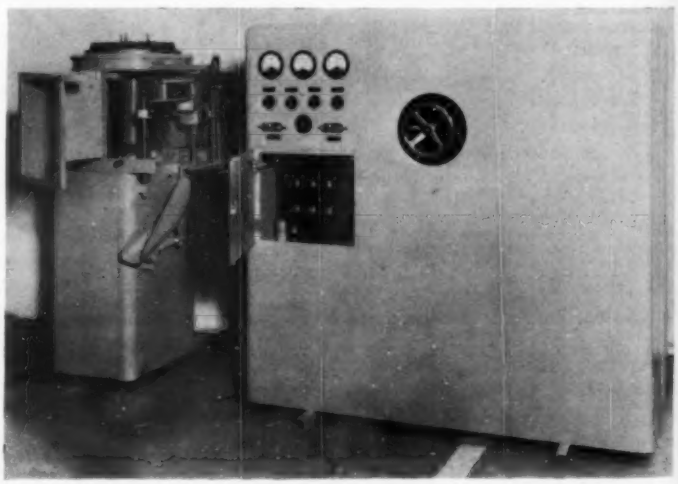


Fig. 6.—Equipment for the continuous heating of the ends of pins for bolt heading.

The rear view of the heater station is shown in Fig. 4, showing the water-cooled capacitors at the bottom, the generator isolator, capacitor knife switches and limit switches fitted at the rear of each coil. A separate heater station housing the three pre-heating coils and the reactor is located adjacent to the main one.

Fig. 5 shows the metal cover housing the motor generator set, which is provided with its own water-cooled heat exchanger. The warm air from the motor and generator passes through the heat exchanger, where it is cooled, and then passes back into the machine. In order that the cooled air may return back into the machine, it is necessary to run these sets inside an enclosure which is reasonably air-tight. A water flow relay, whose dial can be seen behind a small window in the side of the cover, is provided to protect the set against failure of water and an air filter is fitted at one end of the cover.

This installation was designed to take up a minimum of floor space and also so that it could be installed near to the upsetting machines without any special foundations or buildings, and so that it could be operated by semi-skilled operators.

Fig. 8.—Coil for heating 19 mm. diameter pins.

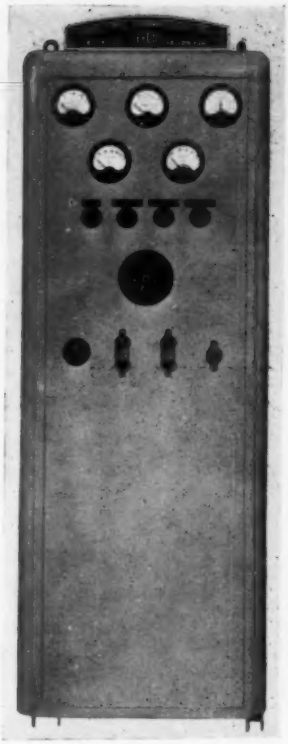


Fig. 9.—Control cubicle for each generator of the equipment shown in Fig. 6.

Heating of Pins for Bolt Heading

The latest type of heater developed for the continuous heating of the ends of bolts is shown in Fig. 6. It consists of a rotary fixture which carries the pins through a channel-type coil where they are heated before being released down a discharge chute. The rotary fixture is connected to a capacitor cubicle by water cooled bus-bars.

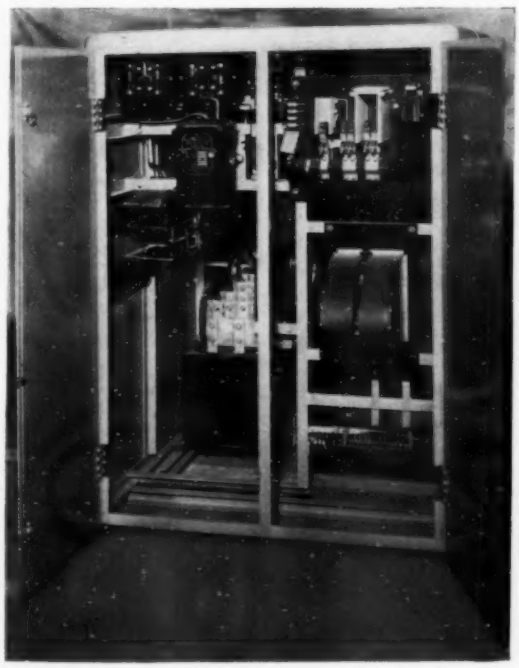


Fig. 7.—View through the end of the capacitor cubicle for the equipment shown in Fig. 6.

The complete installation comprises two 150 kW., 450 V., 10 kc/s. generators, each connected to a pair of heater stations. A generator change-over switch is provided so that the generators may be connected to either pair of heater stations in case of a breakdown. Each heater station is capable of heating the following range of pins: 10 mm. (0·394 in.) diameter to 28 mm. (1·1 in.) diameter and up to 12 in. in length, the heated length in each case being three times the diameter at a temperature of 1,200° C. The maximum output of pins up to 19 mm. diameter is 1,800 per hour.

Independent power control of each heater station was also required, and this has been achieved by fitting inside the capacitor cubicle of each heater station a tapped H.F. auto-transformer which is connected in circuit by means of a 12-position on-load tap change switch. The operating handle for this switch can be seen in the centre of the capacitor cubicle.

On the left of the cubicle are fitted the electrical controls for the rotary fixture motor and the heater station line contactor, together with four knife switches fitted behind an interlocked flap for adjusting the capacitor bank. An H.F. voltmeter indicates the voltage applied to the coil, a kilowatt meter gives the power taken from the line and a kilovar meter enables the capacitor bank to be adjusted to give unity power factor.

Fig. 7 shows a view through the end of the capacitor cubicle. The station isolator and line contactor can be seen on the right and the water-cooled capacitors, rotary fixture motor starter and potential transformers on

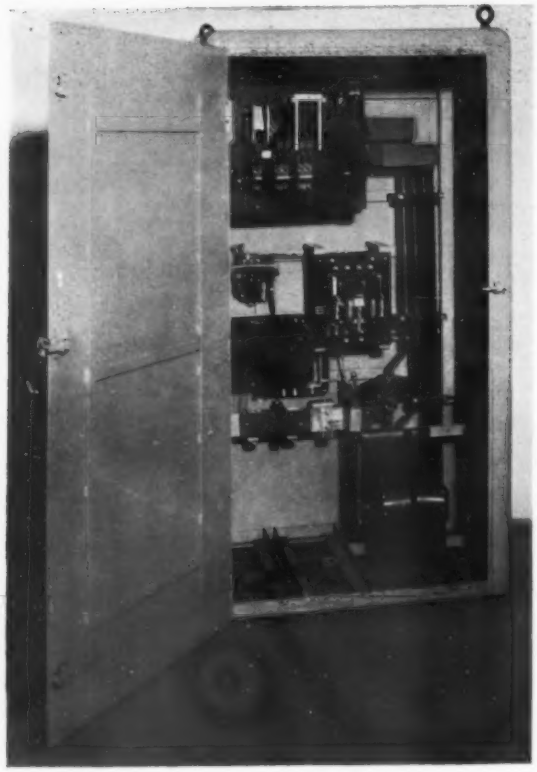


Fig. 10.—Series capacitor cubicle for the equipment shown in Fig. 6.

the left. The rotary fixture consists of a turntable driven by an electric motor via a variable speed gear.

On the top of the fixture is fitted a top ring, which is provided with a number of vertical holes around its edge to locate the pins. Six rings are provided to cover the full range of pins specified, each with varying diameters of holes. The pins, fed by hand into these holes, are carried around until a cam opens the spring-loaded finger fitted beneath each hole, allowing the pins to fall on to an adjustable rotating disc. Each finger is then released and grips the top end of the pin, carrying it through the coil. The relative position of the pin inside the coil, and hence its effective heated length, can be adjusted by lowering or raising the rotating disc. When the end pin is about 1 in. from the end of the coil, its finger is released by another cam and the pin falls down the discharge chute.

Various protective devices are incorporated in the fixture to protect it against damage. A slipping clutch is fitted on the motor shaft to prevent damage to the motor should the mechanism jam, together with a centrifugal switch driven off the motor shaft which prevents power from being applied to the coil unless the motor is running. A further protective device is the fitting of a trip lever over the end of the coil, which is struck by the end pin if it is not released at the correct point. The lever is connected to a limit switch which stops the motor and hence disconnects the H.F. power, thereby protecting the refractory at the end of the coil from damage.

Fig. 8 shows the coil for heating 19 mm. diameter pins. Special adjustable metal guides are fitted to the top of the coil to prevent the pins from rubbing on the inner refractory lining. Three different sized coils are supplied to cover the full range of pins to be heated.

The output of each generator is controlled by the control cubicle shown in Fig. 9. It contains the H.F. meters, field regulator, indicator lamps and push buttons for the main contactor and voltage regulator. An electronic type of over-voltage and over-current relay is fitted in the back. This control cubicle is located adjacent to the pair of heater stations which it controls.

Fig. 10 shows the series capacitor cubicle which houses the generator series capacitor (not shown), isolator, main and field contactors, and carbon pile type voltage regulator. This is located near the generator to which it is connected.

Although only two heater stations are connected in parallel across each generator in this installation, any number may be so connected if desired, provided, of course, that the power of the generator is adequate to cope with the peak demand.

Each pair of heater stations is connected to a common H.F. bus-bar which is supplied with power from one of the generators, whose voltage is controlled at about 450 V. by the voltage regulator. Once the voltage has been set, no further adjustment of the generator is required, as the power output of each heater station is controlled by its own tap change switch.

Acknowledgments

The author wishes to thank the Directors of the Electric Furnace Company for permission to publish details of these high frequency induction heating plants.

British Internal Combustion Engine Research Association

At the Annual General Meeting of the B.I.C.E.R.A., held recently, the Rt. Hon. the Viscount Falmouth, was re-elected President.

Air Commodore, F. R. Banks, Dr. F. S. Dovey, Sir Lynden Macassey, Vice Admiral (E.) The Hon. Sir Denis Maxwell, Major-General H. E. Pyman and Lieutenant-General Sir Frederick Wrisberg were re-elected as Vice-Presidents.

A new and small representative Council was elected at the meeting, the newly elected members being: Messrs. H. N. G. Allen (Chairman), Miles Beevor, G. W. Bone, F. A. Perkins, C. G. Tangye and A. C. Yeates. Mr. C. A. Spencer represents the D.S.I.R. on the Council.

Worcester Bench Power Presses

The Stourbridge (Worcs.) firm of Jones & Attwood, Ltd., have acquired the sole manufacturing and selling rights for the well-known range of sturdy 2-, 3- and 6-ton bench power presses from the Mining Engineering Co., Ltd., Worcester. Jones & Attwood, Ltd. have previously gained considerable experience in the manufacture of these machines as sub-contractors to the Mining Engineering Co., Ltd.

All three sizes of these machines are already in production and are available with either lineshaft drive or fully motorised. Arrangements are being made to step up production considerably in order to meet increasing sales.

Sintered Aluminium with High Strength at Elevated Temperatures*

By Dr-Ing. R. Irmann

(*Neuhausen am Rheinfall*)

Sintered compacts prepared from pure aluminium powder are much stronger at room temperatures than pure aluminium itself, and are superior at elevated temperatures to the usual aluminium alloys. In this article the author discusses factors involved in the production of this material and compares its properties with those of pure aluminium and of a number of its alloys.

SINTERING processes are, in general, employed for the production of compacts from metals, metalloids, metal oxides, silicates or organic materials in the form of powder. Powder metallurgy permits the production of high precision finished components, and for certain materials it is the only possible method of producing a given form. In this connection, the manufacture of sintered bodies from high melting point metals such as tungsten or molybdenum, or from mixtures of metal carbides and oxides, may also be mentioned.

In this paper, the theory of powder metallurgical processes will not be considered. The "starting materials" of these processes are powders of a certain grade and shape from which finished articles are produced by the application of pressure and heat. Heat and pressure may be applied simultaneously or the heat may be applied after pressing. It will be clear that a well-compacted powder facilitates sintering, whilst the presence of gas- or air-holes, grease, oxides or other non-metallic impurities has a detrimental effect and may even make sintering impossible. To ensure good compacting, the metal powder must be of a suitable particle shape and size, and to permit satisfactory sintering no more than a certain amount of surface impurities can be tolerated.

The properties obtained in sintered metals do not usually reach the values achieved by casting, rolling, pressing or drawing processes.

Aluminium is not normally suitable for sintering because of the presence on its surface of a thick, adherent oxide film. The thickness of this film depends on the purity of the metal, the oxygen content of the oxidizing medium and the time and temperature of exposure. When 99·6% pure aluminium is exposed to the air for 20 days at room temperature, the thickness of the oxide film will have the value shown in Fig. 1. In the case of Raffinal (99·99% purity), the thickness of the film will be somewhat less. The exposure to air of commercial aluminium of 99·3–99·5% purity produces an oxide film about 0·01 micron thick.

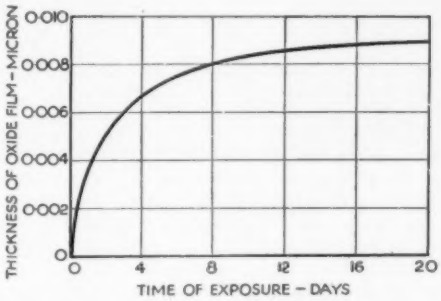


Fig. 1.—Thickness of oxide film on 99.6% pure aluminium on exposure to the atmosphere (after W. H. J. Vernon, Trans. Far. Soc., 1927, vol. 23, 152).

For the manufacture of powders, mechanical or physico-chemical procedures are generally used. For aluminium powder, mechanical processes are employed as shown in Fig. 2. By atomizing or dispersing a thin stream of liquid aluminium by means of compressed air or steam, a coarse, granular powder can be obtained, characterized by particles of irregular shape having a size about 200 microns (Procedure 1). By vigorously shaking the metal while it is in the pasty stage of solidification (Procedure 2), particles of similar dimensions but of more pointed shape are obtained. If finer powder is required, Procedure 3 is employed, in which foil or atomized powder is reduced to flakes by stamping or ball milling. In the ball mill, the operations are carried out in an atmosphere containing about 8% oxygen. In both the stamping and ball milling procedures, an addition of stearic acid is necessary to

* Swiss patents 250,118 and 259,878 and patents in other countries.

	Condition of Original Material	Method	Particle Shape	Particle Size	Application
1	Molten	Atomizing or dispersing	Granular	More than 200 microns	Thermit process Aluminium paint
2	Pasty, near melting point	Agitating	Granular	More than 200 microns	Thermit process Deoxidiser
3	Solid, at room temperature	Stamping or ball-milling	Flakes	1·0—50 microns	Aluminium paint Pyrotechnics
4	Solid, at room temperature	Wet milling in mineral spirit	Flakes	1·0—50 microns	Aluminium paint

Fig. 2.—Mechanical methods for the production of aluminium powder.

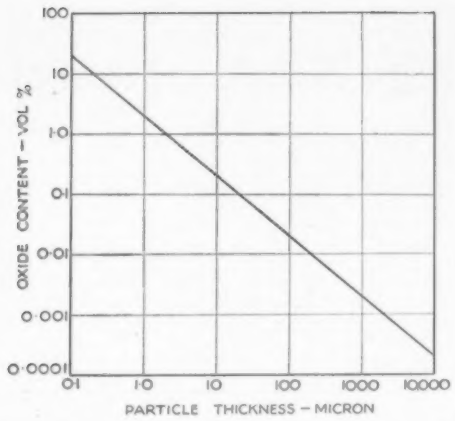


Fig. 3.—Oxide content of aluminium flake powder in relation to particle thickness.

facilitate the production of flakes and to avoid the risk of explosion. Powder for pyrotechnic purposes is made only by these two procedures, the product generally requiring to be degreased in vacuum. The fourth procedure, the so-called "wet-milling" process, is carried out in mineral spirits and produces a product suitable for paint.

Tests with powders of different particle size (different insofar as the size can be defined by sieving tests) show that as the particle size decreases, the oxide content increases. Assuming an oxide layer of 0·01 micron thick on each side of the flake, there is a linear relation between the oxide content (volume %) and particle thickness when plotted on a double logarithmic scale as shown in Fig. 3. It will be seen that for a particle thickness of 10^{-1} micron the oxide content is about 20%, for 1 micron about 2%, and for 10^4 microns (10 mm.) only about 0·0002%.

Sintered bodies can only be produced from powders of less than 0·1 micron particle thickness under special conditions of pressure and temperature. Because of the small particle size, the low packing density and the high oxide content of these powders are both unfavourable to

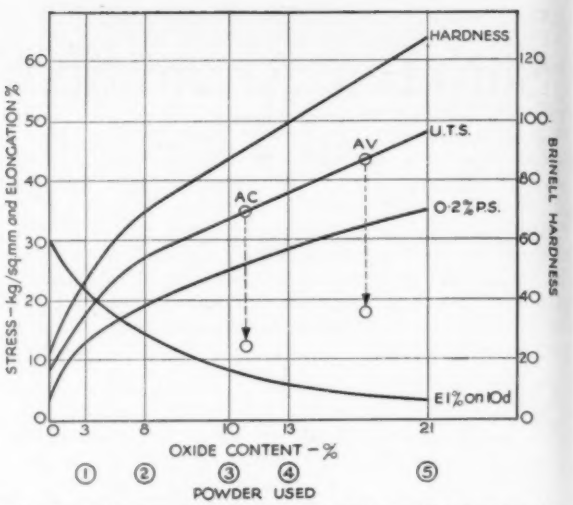


Fig. 5.—Influence of oxide content and particle size on the strength of sintered aluminium compacts at room temperature.

compacting followed by sintering. Due to the plasticity of the single aluminium particles, however, good compacting is possible because plastic deformation breaks the oxide skin and this enhances the sinter process. Sintering is, therefore, only possible when pressure and increased temperature are applied simultaneously, sintering being complete only as a result of the additional deformation obtained in extrusion.

Sintered Bodies in Aluminium

By Procedures (*a*) or (*b*) of Fig. 4 (*i.e.* cold precompacting of the powder followed by hot pressing and final extrusion (*a*) or direct pressing in die (*b*)) it is possible to prepare sintered compacts that will have properties similar to those of either pure aluminium or heat-treated wrought aluminium alloys depending on the grade of the powder used. This is contrary to normal experience in powder metallurgy where the properties obtained are lower than those of the same material in the cast or forged condition.

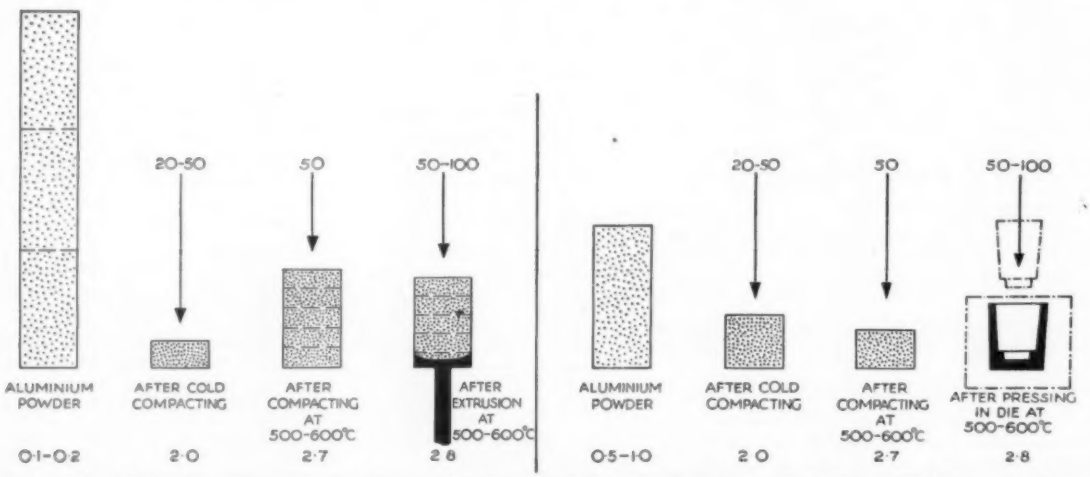


Fig. 4.—Manufacturing processes for the production of sintered compacts in aluminium. The figures below the sketches indicate the apparent specific gravity, whilst those above the arrows are in kg./sq. mm.

Fig. 6.—Atomized powder. × 1,000

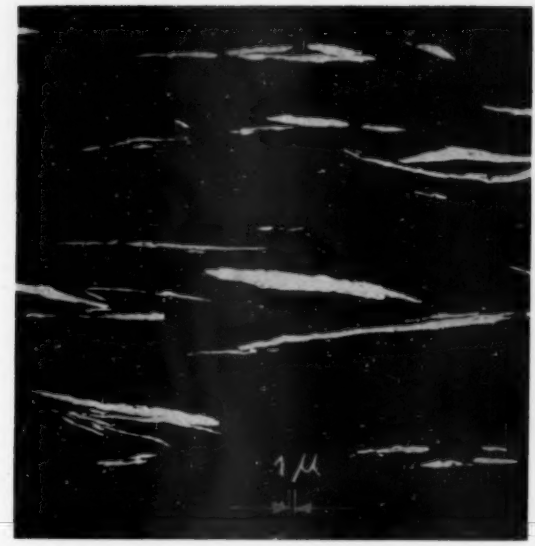


Fig. 7.—Flake powder. × 1,000

Fig. 5 shows the proof stress, ultimate tensile stress, hardness and elongation as a function of oxide content for extruded sintered compacts prepared from different grades of aluminium powder. It will be seen that when no oxide is present the properties obtained are similar to those of annealed aluminium alloys. Powders 1–5 are characterized by a decreasing particle size and, therefore, increasing oxide content, Powder 1 having the coarsest particles and Powder 5 the finest. The properties of heat-treated Anticorodal (Ac, Al-Si-Mg alloy) and Avional (Av, Al-Cu-Mg alloy) are also shown. Any of the pure aluminium sintered bodies will be seen to give properties the equal of those of the heat-treated alloys except in the case of elongation, which is lower and decreases with increasing oxide content. If the heat-treated alloys are heated for a few hours at about 400° C., the strengthening brought about by heat-treatment is lost and, as shown by the arrows, the property values fall to those of the annealed materials. In the case of the sintered bodies, however, prolonged heating (*e.g.* for several months at 500° C.) has practically no effect on the properties as will be shown later.

The fact that sintered compacts prepared from pure aluminium powder are much stronger at room temperature than pure aluminium itself, and outstandingly strong at elevated temperatures, was shown in a previous paper to be due to the very small particle size limiting the free path for slip. When pre-pressed and sintered, the oxide skin surrounding the powder particles is punctured to an extent sufficient to permit adequate welding of the particles. Essentially, however, the particles are still separated by oxide skins and therefore grain growth and recrystallisation cannot occur. We have called these aluminium sintered bodies SAP, which denotes " Sinter-Aluminium-Pulver."

Nature of the Aluminium Powder

Since the properties of sintered aluminium compacts are dependent on the form, size and surface area of the powder, as well as on the oxide content, it is necessary to consider these factors in greater detail.

A powder obtained by atomizing liquid aluminium is shown in Fig. 6 at a magnification of 1,000 diameters and it will be seen to consist of spherical and ellipsoidal particles. Fig. 7 shows the typical flake powder produced by stamping, whilst Figs. 8 and 9 show the same two powders photographed at a magnification of 10,000 diameters through an electron microscope (photographed at the Electron-Microscopy Laboratory of Berne University). From Fig. 8 it will be seen that the atomized powder is not penetrated by electrons and the particle size is therefore greater than 1·0 micron. Powder produced by stamping, however, (as shown in Fig. 9) is penetrated by electrons and the thickness of the flakes must therefore be of the order of 0·01 micron.

If the powder is reheated in a current of hydrogen chloride, the aluminium sublimes as aluminium chloride ($AlCl_3$) and the oxide film remains unchanged. From the electron-microscope photograph shown in Fig. 10 it can be deduced that the oxide film is about 0·03–0·3 micron thick, whereas in Fig. 11 it is less than 0·01 micron thick.

The powder shown in Fig. 6 contains 3% by weight of oxide, that in Fig. 7 10%. The shape and thickness of the particles, and the thickness of the oxide layer on these powders are shown graphically in Fig. 12. The oxide layer on the atomized powder is crystalline (cubic) and brittle. As a result of the mechanical reduction during the stamping operation, the oxide film is broken down and distributed in finely divided form between adjacent flakes. This occurs even when only traces of oxide are present. The oxide film formed on flake powders at room temperature, however, is amorphous and clear and, to a certain extent, ductile.

As shown in Fig. 5, the oxide content increases with decreasing particle size, and the mechanical properties also increase in the same manner. If a powder containing 8% of oxide at room temperature is heated at 300° C. in air, not only is the oxide content increased but the properties of a sintered compact produced from the powder are also increased, as shown in Fig. 13. It is clear, therefore, that for a powder of given particle shape and

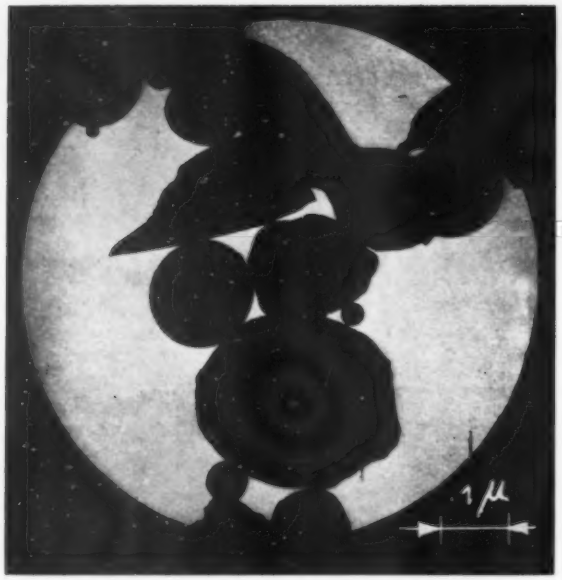


Fig. 8.—Electron micrograph of atomized powder. × 10,000

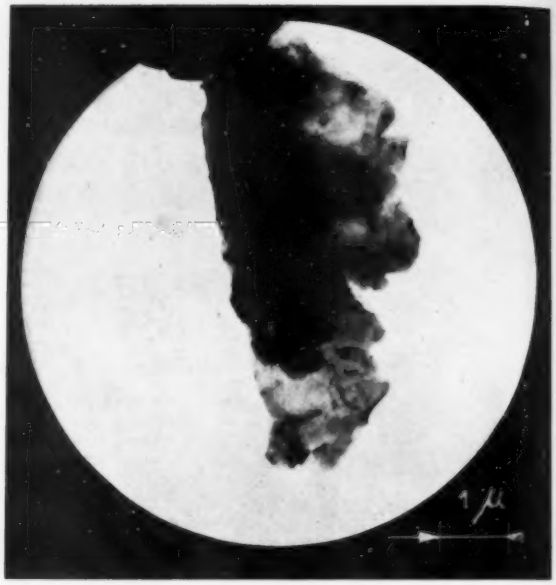


Fig. 9.—Electron micrograph of flake powder. × 10,000

size, an increase in properties can be obtained by increasing the oxide content. During stamping or ball milling, the particle size decreases as the process is prolonged and the properties and oxide content can therefore be plotted against the time of manufacture as in Fig. 14. This figure exhibits a feature of particular interest, namely, that the particle size first decreases but after a certain length of time increases. This is contrary to experience and shows that it is quite impossible to give the particle size in any particular grade of powder, as different results can be obtained depending on the particle shape and the sieving method used.

Figs. 15 and 16 show powders after 4 and 8 hours working, the later appearing the coarser. This powder, however, consists of a large number of smaller particles (Fig. 17) which, during the milling process have formed agglomerates of apparently large volume but with a much greater surface area than single particles of the same volume. If the surface area were measurable, then the properties would be related, not to the particle size, but to this surface area. It is believed that, for compacts prepared by the same method from the same grade of powder, the surface area can be deduced from the oxide content.

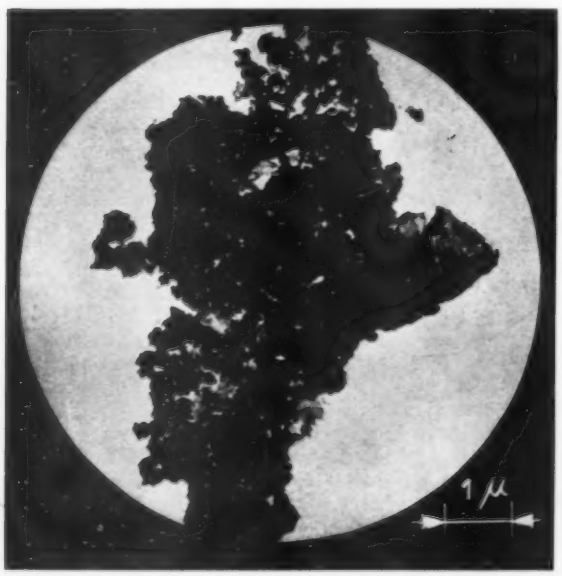


Fig. 10.—Electron micrograph of oxide film on atomized powder. × 10,000

Fig. 11.—Electron micrograph of oxide film on flake powder. × 10,000

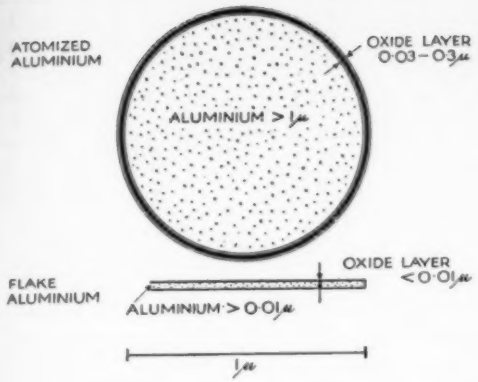


Fig. 12.—Atomized powder and flake powder (schematic).

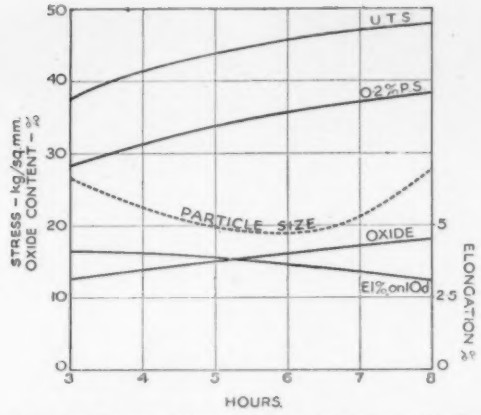


Fig. 14.—Influence of time in manufacture on the particle size and oxide content of aluminium powder and on the mechanical properties of SAP.

It is not surprising to find that the oxide content of a powder of a specific particle shape and size (and therefore of a specific surface area) can be increased by heating. It is known that the oxide content of a powder of such a grade increases markedly on exposure at room temperature. The increase in oxide and the parallel increase in properties seem to indicate that the oxide film normally produced at room temperature does not suffice to prevent recrystallisation entirely. The thickness of the oxide layer may grow by storing at room temperature or by heating, but further attack occurs by subsequent oxidation of those particles which are strongly fissured. In any case sintering is retarded by a given oxide content so that the properties decrease whereas the hardness increases.

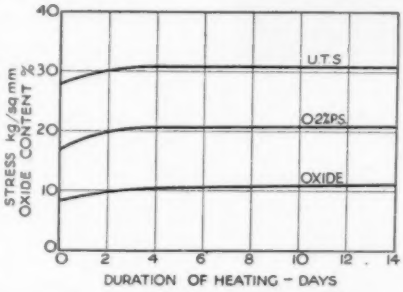


Fig. 13.—Effect of heating aluminium powder at 300° C. on the oxide content and mechanical properties of SAP.

Mechanical Properties of SAP

The properties of SAP were determined on an extruded bar manufactured from a powder of a grade intermediate between Powders 3 and 4 of Fig. 5.

(*A*) Static Strength at Room Temperature.

The tensile properties of extruded SAP prepared from powders of various grades, are shown in Fig. 5. These properties can be seen to equal those of heat-treated Anticorodal or Avional. Moreover, they fall only slightly after heating the material for one month at 500° C., whereas the heat-treated alloys are almost completely softened after heating for one day at 400° C. The results are recorded in Table I.

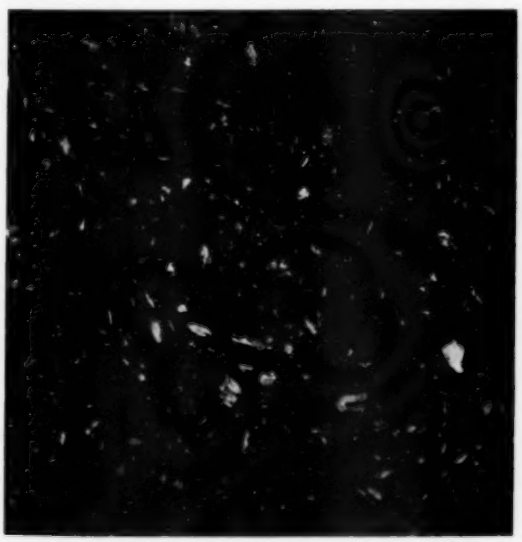


Fig. 15.—Flake powder after 4 hours working. × 100

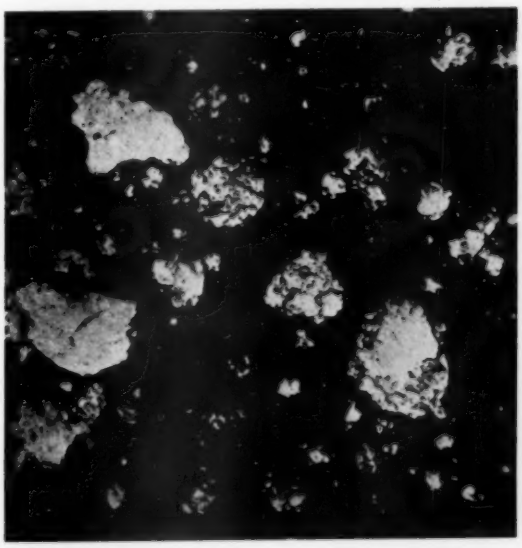


Fig. 16.—Flake powder after 8 hours working. × 100

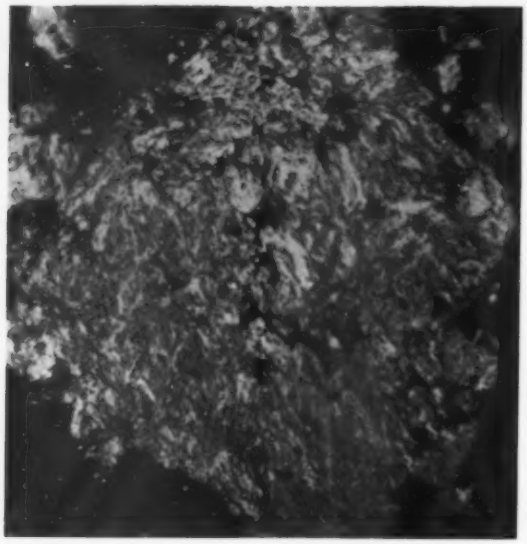


Fig. 17.—Flake powder after 8 hours working. × 1,000

TABLE I.—STATIC STRENGTH OF SAP AND ALUMINIUM ALLOYS.

Material	Condition	0·2% Proof Stress kg/sq. mm.	Ultimate Tensile Stress kg/sq. mm.	Elongation %on 10 d	Hardness kg/sq. mm.
SAP	As extruded	23–27	32–36	6–8	100–110
	After heating for One month at 500° C.	22–26	31–35	6–8	95–105
Anticorodal (Al-Si-Mg)	As heat-treated	27–38	32–42	10–14	90–120
	After heating for One day at 400° C.	4–8	10–14	20–30	30–40
Avional (Al-Cu-Mg)	As heat-treated	26–36	40–48	12–20	100–125
	After heating for One day at 400° C.	8–12	19–25	10–20	50–65

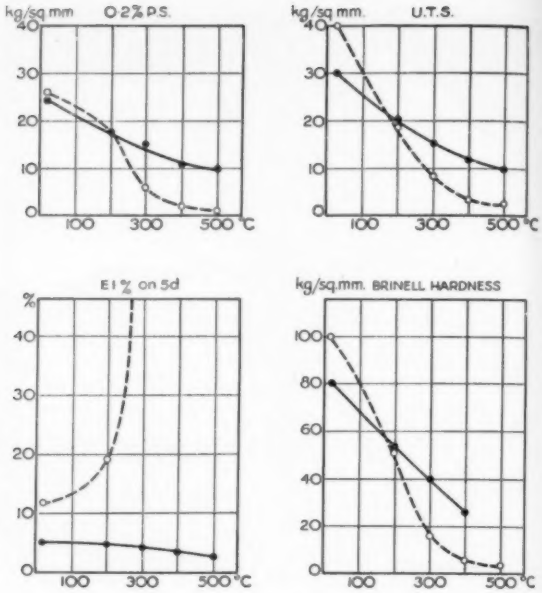


Fig. 18.—Mechanical properties of SAP (continuous curves) and heat-treated Avional M (dotted curves) at elevated temperatures (soaked at temperature for 30 days before testing).

(*B*) STATIC STRENGTH AT ELEVATED TEMPERATURES (30 DAYS SOAKING).

The tensile strength of SAP at temperatures up to 500° C. is quite abnormal for pure aluminium. In Fig. 18 the values obtained are shown in comparison with heat-treated Avional M, both materials being soaked for 30 days before testing. The proof stress, ultimate tensile stress and hardness fall as the temperature is increased but it is to be noted that at 500° C. the properties of SAP are much higher than those of Avional. The elongation—which for a polycrystalline material usually

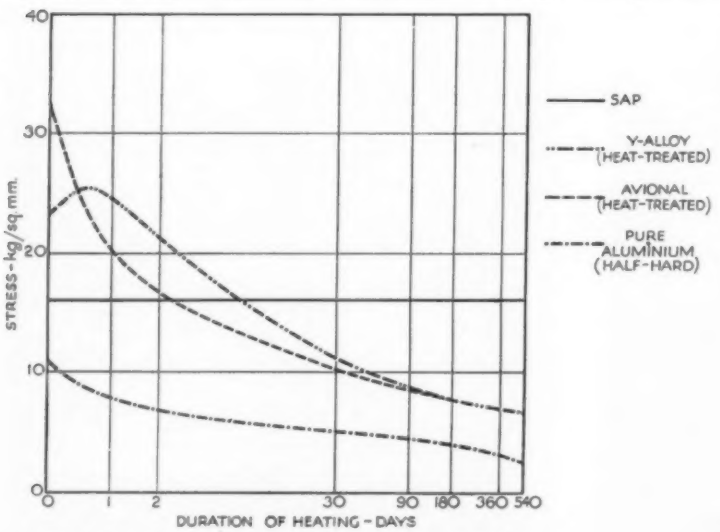
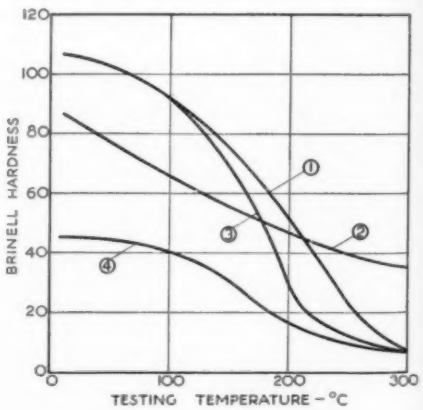


Fig. 19.—0.2% proof stress at 250° C. of SAP, Y-Alloy (heat treated), Avional (heat treated) and pure aluminium (half hard) after prolonged soaking at the testing temperature.



1.—Y-Alloy (heat treated).
2.—SAP.
3.—Avional (heat treated).
4.—Avional (annealed).

Fig. 20.—Hardness of SAP, Y-Alloy and Avional (both heat treated), and annealed Avional, at elevated temperatures, the load being maintained for 30 days at the testing temperature.

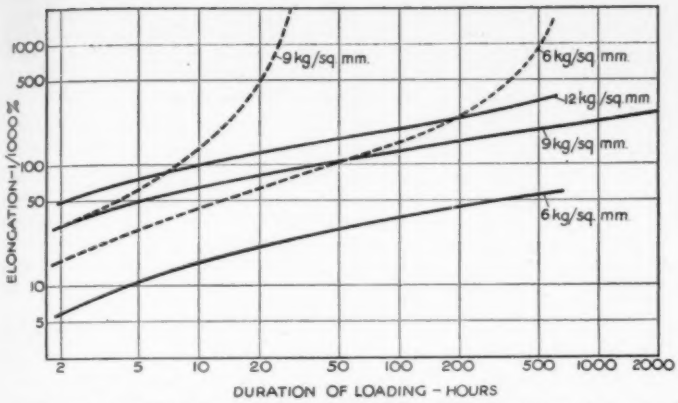


Fig. 21.—Elongation of SAP (continuous curves) and heat-treated Avional M (dotted curves) under prolonged loading at 250° C.

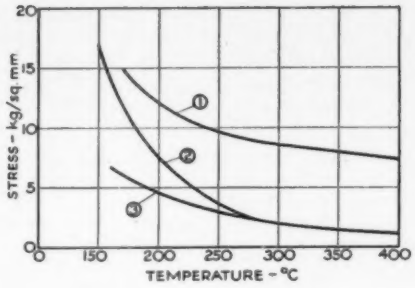


Fig. 22.—Creep strength of SAP, Avional M and Y-Alloy (both heat treated) and annealed Avional M at temperatures up to 400° C.

increases markedly at elevated temperatures—shows a tendency to decrease in the case of the sintered material.

(*C*) Static Strength at Elevated Temperature (250° C.) After Prolonged Heating.

The superiority of SAP over Avional and Y-alloy is clearly demonstrated in Fig. 19 which shows the 0·2% proof stress results after prolonged soaking at 250° C. The proof stress of SAP remains constant and after soaking for 540 days has a value about 2½ times that of Avional and Y-alloy and about 8 times that of pure aluminium.

(*D*) Static Properties Under Prolonged Loading at Elevated Temperatures.

Hardness.—The hardness of SAP at temperatures up to 300° C. is shown in Fig. 20 in comparison with heat-treated Avional M and Y-alloy. The hardness values were determined on 40 × 40 × 10 mm. specimens using a steel ball indenter under a load of 250 kg, the load being maintained for 30 days at the testing temperature. Under these conditions, the hardness of Avional M falls below that of SAP at a temperature just under 200° C., whilst Y-alloy, which is noted for its hot strength, is softer than SAP at temperatures above about 220° C.

Creep strength.—The creep behaviour of SAP and heat-treated Avional M under stresses of 6, 9 and 12 kg./sq. mm. was determined on specimens of 10 mm. diameter, the temperature and duration of testing being 250° C. and up to 2,000 hr., respectively. The rate of elongation and the total elongation were determined and the results obtained are shown in Fig. 21. At 12 kg./sq. mm. it was impossible to measure the elongation of Avional since the specimen broke after a few hours whereas SAP showed a rate of elongation at 30 hr. of only $1{\cdot}5 \times 10^{-3}$ %/hr. At 9 kg./sq. mm. the rate of elongation of Avional is 400×10^{-3} %/hr. compared with $0{\cdot}9 \times 10^{-3}$ %/hr. for SAP. At 6 kg./sq. mm. the rate of elongation of Avional is more than 5 times that of SAP. After 500 hr. at 6 kg./sq. mm. the total elongation of the SAP specimen was 0·056%; that of the Avional specimen was 0·91 % and increasing rapidly. At 9 kg./sq. mm. SAP elongated by only 0·27% in 2,000 hr. As the creep strength at 250° C. it would be safe to accept a value of 9 kg./sq. mm. for SAP, whereas for Avional a safe value would be less than 6 kg./sq. mm.

In the case of a material such as SAP, the creep rate,

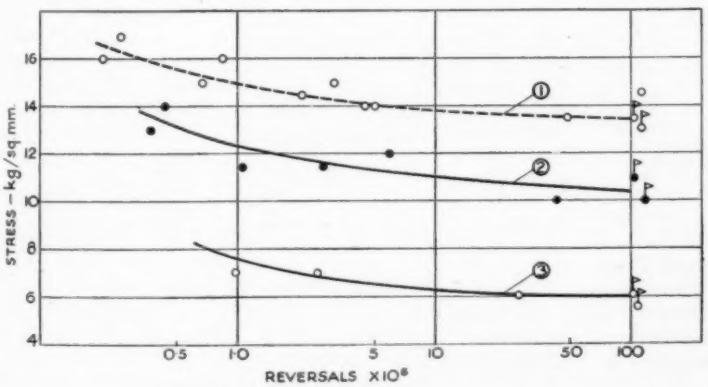


Fig. 23.—Rotating bending fatigue strength of SAP, heat-treated Avional M and Anticorodal B, and half hard pure aluminium.

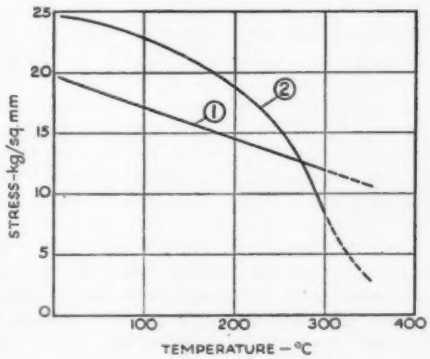


Fig. 24.—Repeated loading fatigue strength of SAP and heat-treated Y-Alloy at 20-350° C.

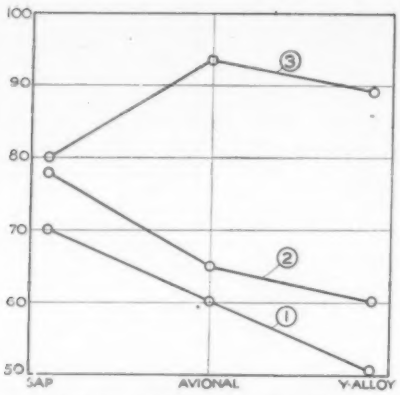


Fig. 25.—Electrical conductivity (1), thermal conductivity (2), and thermal expansion (3) of SAP, heat-treated Avional M and heat-treated Y-Alloy, expressed as percentages of the values for 99.5% pure aluminium.

and the total elongation at a selected temperature and under various loads, can be measured by a rapid test such as the so-called "Rohn-method," in which the test piece is suspended in a furnace whose heating current is controlled by the elongation of the test piece. Within a few days a steady temperature is reached which, for a material such as SAP, will be practically independent of the period of heating. In the case, however, of heat-treated alloys such as Avional, the period of heating will have a certain influence on the resulting temperature and the alloy will invariably attain the softened condition.

The results obtained in this manner for SAP and for both heat-treated and annealed Avional are shown in Fig. 22, the time of testing being 30 days. Recent experiments show that values for heat-treated Y-alloy fall on the curve for heat-treated Avional, the creep limit of Y-alloy lying well below that of SAP.

(*E*) Fatigue Strength at Room and Elevated Temperatures.

Rotating bending fatigue strength.—The rotating bending fatigue strength of SAP at room temperature for round polished test pieces 9·5 mm. diameter (Fig. 23) is equal to that of Anticorodal B (Al-Si-Mg), lower than that of Avional, and nearly twice that of pure aluminium. The influence of notches is shown in Table II.

TABLE II.—FATIGUE STRENGTH OF SAP AND ALUMINIUM ALLOYS.

Material	Fatigue Strength at 100×10^6 Cycles kg/sq. mm.		Notch Sensitivity Factor
	Unnotched	Notched	
Avional M—heat-treated	13·5	9·4	1·44
Anticorodal B—heat-treated	10·5	9·0	1·17
SAP	10·5	7·5	1·40
Pure aluminium, half-hard	6·0	4·5	1·33

Repeated loading fatigue strength (pulsating stress, minimum zero).—A comparison of the repeated loading fatigue strength of SAP and heat-treated Y-alloy at 2×10^6 cycles and temperatures from 20–350° C. is shown in Fig. 24, the duration of the test being 96 hr. It will be seen that the curves cross at about 270° C. The most recent tests at 350° C. have given values indicated by the dotted portions of the curves. The repeated loading fatigue strength of SAP at this temperature is approximately 11 kg./sq. mm., compared with 2·5 kg./sq. mm. for Y-alloy. If the tests are prolonged to 10×10^6 cycles, Y-alloy will give the value for completely annealed material whereas SAP will show no decrease in fatigue strength.

Physical Properties

(*A*) Electrical and Thermal Conductivity at Room Temperature.

The electrical conductivity of SAP is greatly influenced by the oxide content and also by the manufacturing process. It is clear that with increasing oxide content the electrical conductivity decreases due to structural discontinuities produced by the oxide; this is shown in Table III.

TABLE III.—EFFECT OF OXIDE CONTENT ON THE ELECTRICAL CONDUCTIVITY OF SAP

Oxide Content %	Electrical Conductivity $\frac{m}{\text{ohm} \times \text{mm.}^2}$
10	25·9
13	23·1
21	18·4

During the manufacture of extruded bar (Process (*a*) of Fig. 4), the material undergoes a more or less thorough working. SAP produced by Process (*b*) of Fig. 4 has a somewhat lower conductivity. The dispersion of the particles in the finished product, which depends on the type of powder used, affects the conductivity, and in a similar manner the thermal conductivity is affected both by the type of powder used and by the method of manufacture.

The important feature to note is that SAP, in addition to having high strength at room temperature, and especially at elevated temperatures, has an electrical and thermal conductivity more closely approaching those of pure aluminium than of aluminium alloys. This is clearly shown in Fig. 25, where the electrical and thermal conductivities of SAP, Avional and Y-alloy are expressed as percentages of the values for 99·5% pure aluminium. It will be seen that the electrical conductivity of SAP is 70% that of pure aluminium compared with 50% for Y-alloy, while the thermal conductivity is 80% compared with 60% for Y-alloy.

(*B*) Thermal Expansion.

As shown in Fig. 25, the thermal expansion of SAP over the range 20–100° C. is about 80% that of pure aluminium and is appreciably lower than that of Avional and Y-alloy. The heating of SAP does not cause the permanent dimensional change due to lattice transformation commonly observed in aluminium alloys.

Corrosion Characteristics

So far, tests show that SAP is as resistant to corrosion by the atmosphere, water-vapour and weak acids as pure aluminium, and as resistant to sea-water as Anticorodal.

Applications of SAP

In considering the uses of SAP prepared from pure aluminium the following properties are of special interest:

Specific weight
Hot strength
Thermal conductivity
Thermal expansion
Electrical conductivity
Corrosion resistance

The foregoing discussion has been limited to SAP prepared from pure aluminium powder and it may be asked if it would not be possible to use an alloy powder to produce a heat-treatable SAP with even higher properties. Such a material would, however, have a lower electrical and thermal conductivity, and, like the heat-treatable cast and wrought aluminium alloys, its elevated temperature properties would be lost on heating. On the other hand, in certain cases an alloyed SAP would be interesting.

The uses of SAP prepared from pure aluminium appear to be in those fields where, up to the present, aluminium and aluminium alloys have not been applicable because of their lack of hot strength. The physical properties of SAP, *e.g.* high thermal conductivity, low thermal expansion and dimensional stability on heating, indicate that it should be specially interesting as a piston material. Compared with well-known aluminium piston alloys, SAP has the additional advantage that its melting point is 150° C. higher and this lessens the danger of overheating. The development of crown cracks which are especially noticeable in diesel-pistons because of the high operating temperature can be avoided by the use of SAP with its high melting point and appreciably higher hot strength. Moreover, the cycles of heating and cooling experienced by the piston in operation subject the crown to alternating stresses, and from this point of view, SAP will be clearly superior to the known aluminium alloys because of its higher creep limit and repeated loading fatigue strength. Where the production of a complete piston in SAP is not practicable, an insert of SAP may be used to provide high hot strength in the crown. Inserts can be produced economically and conveniently by the method shown in Fig. 4 (*b*). Compressor blades are now being manufactured in large quantities from aluminium alloys, but some designers, however, have not considered using aluminium because of its inadequate properties at elevated temperatures. To them, SAP is clearly a material of great interest.

Because of the nature of the starting material and the method of working, a component produced in SAP will cost more than the same component produced in aluminium alloy. Moreover, production is still limited by the supplies of material available.

New and Revised British Standards

Rolled Copper Sheet and Strip for General Purposes. (B.S.899 : 1952)

Price 2s. 6d.

In this revision, which includes provisions for annealed, half hard and hard conditions, the mechanical properties have been modified and elongation requirements have been added, as well as an embrittlement test for deoxidized material. Other minor amendments have been made in order to bring the standard as far as possible into line with the revised edition of B.S.1432, "Copper for electrical purposes (sheet and strip)" which will be issued shortly.

Raw Copper. (B.S's. 1035–40, 1172–4 and 1861 : 1952)

Price 4s.

The British Standards Institution has just issued in one booklet the following 10 standards for raw copper :—

B.S.1035.	Cathode copper.	
B.S.1036.	Electrolytic tough pitch high conductivity copper.	
B.S.1037.	Fire refined tough pitch high conductivity copper.	
B.S.1038.	99·85% tough pitch copper.	conductivity not specified
B.S.1039.	99·75% tough pitch copper.	
B.S.1040.	99·50% tough pitch copper.	
B.S.1172.	Phosphorus deoxidized non-arsenical copper.	
B.S.1173.	Tough pitch arsenical copper.	
B.S.1174.	Phosphorus deoxidized arsenical copper.	
B.S.1861.	Oxygen-free high conductivity copper.	

This includes revised editions of B.S.1035–40 first issued in 1942, revised editions of B.S.1172–4 published separately in 1944, and a new specification B.S.1861 for oxygen-free high conductivity copper.

Apart from amending the upper limit for phosphorus in B.S.1172 and B.S.1174 only minor changes have been made to both the earlier series but, in some cases, the number of significant figures quoted for the limits have been altered so that the correct degree of accuracy is implied.

Electroplated Coatings of Tin. (B.S.1872 : 1952)

Price 2s. 6d.

The British Standards Institution has issued a further publication in the series which is being prepared covering electroplated coatings of various metals. The present document deals with electroplated coatings of tin. It provides for coating of this metal on fabricated articles of iron, steel, copper and copper alloys and covers five classes of coating according to the use to which the coating is to be put. It also provides details of samplings, finish, solderability, thickness, adhesion and heat treatment, together with the necessary methods of test.

Wrought Light Alloys L.62, L.63, L.64 and L.65

The British Standards Institution has recently published the following British Standards in the aircraft series :—

B.S. L.62. Aluminium-copper-magnesium-silicon-manganese alloy tubes (solution treated and aged at room temperature). (Replacing B.S. 5T.4). Price 1s.

B.S. L.63. Aluminium-copper-magnesium-silicon-manganese alloy tubes (solution treated and precipitation treated). (Replacing D.T.D.464A). Price 1s. 6d.

B.S. L.64. Aluminium-copper-magnesium-silicon-manganese alloy bars, extruded sections and forgings (solution treated and aged at room temperature). (Replacing B.S. 6L.1 and 2L.39). Price 1s. 6d.

B.S. L.65. Aluminium-copper-magnesium-silicon-manganese alloy bars, extruded sections and forgings (solution treated and precipitation treated). (Replacing D.T.D.364B). Price 1s. 6d.

Copies of these standards are obtainable from the British Standards Institution, Sales Branch, 24, Victoria Street, London, S.W.1.

Aluminium Alloy Barges for the Congo

AT their works at West Molesey, Surrey, Thorpe Bros. (Bessborough Works), Ltd., are now completing an order for some 60 aluminium alloy barges for the Belgian Congo. These barges are to be used for the transportation of general cargoes from the upper reaches of the river down to the coastal ports. Some seven years ago, the clients for whom these barges are being made, approached Thorpe Bros. with a problem which was causing them considerable trouble and heavy expense. This problem was the failure of their river craft operating on the Congo. Timber barges, owing to attack by Teredo worm and Limnoria, had a service life of only 2–3 years duration, whilst the corrosive attack of the waters of the Congo on steel craft limited their life to an average of 5–7 years. In considering what materials of construction might be used, aluminium alloys were suggested, and exhaustive tests showed that they possessed the qualities needed for Congo service—high strength coupled with corrosion resistance and freedom from worm attack.

Another extremely important advantage which craft in light alloys have over the steel and timber barges is the shallow draft. During the dry seasons the river becomes very shallow and, in consequence, steel and wooden barges can only be operated for about five months per year—during and immediately after the rains. The Moseley type of barge, constructed of light alloy has been found to be serviceable—fully loaded—for nine months out of the twelve. There, is too, the added advantage that the power requirements of the propelling tug are considerably reduced.

Perhaps the chief interest that these barges have is not so much that they have been fabricated in aluminium alloy, for that is something which is fast becoming traditional for certain types of craft, but that they have been so produced at a highly competitive price. Thorpe Bros. have fitted out the shops in which the barges are being constructed to take every possible advantage of the ease of working and handling of aluminium alloys, and the delivery to site of plates ready cut to the required size, within very close tolerances, has enabled a high degree of prefabrication of sides, bulkheads, etc., to be carried out. The use of large plates ($\frac{3}{16}$ in. thick and up to 30 ft. in length) supplied by the British Aluminium Co. in B.A.M27 (NP/5), has reduced the amount of jointing needed and has, therefore, simplified production. The result of all these economies is an encouraging cut in costs.

The Molesey barge is 77 ft. overall length, by 11 ft. 6 in. beam, with a depth of gunwale of 4 ft. 6 in. and the cubic capacity of the two holds, each 30 ft. in length, is 2,640 cu. ft., which with a cargo of 40 cu. ft./ton gives a carrying capacity of 66 tons. Constructed on the longitudinally framed system of plate and section, the arrangement of the barge includes three watertight bulkheads; two holds, each with an opening, complete with light alloy beams and covers; and two peaks. NP/5 material is specified for the plates, and HE.10 for extrusions. The barges are shipped in two halves, because on arrival in the Congo they have to be transported by rail for a considerable distance, because of unnavigable stretches of river. In the course of this journey, railway tunnels have to be negotiated—hence the necessity for paying attention to overall size. The joint consists in a tee section already riveted to one half, the other half being riveted to the tee on site. The midships deck plate is also left off until final assembly, and, by overlapping the two halves substantially as it does, it acts as a further butt plate between them, chiefly effective under hogging conditions. The only other work carried out on site is the making and fitting of the timber hold linings, designed to provide additional protection against damage, and easily replaceable.

General view of light alloy barge at the makers' works prior to shipping to the Congo.

B.W.R.A. Summer School

THE BRITISH WELDING RESEARCH ASSOCIATION recently held its second Summer School on Welding, at Ashorne Hill, Leamington Spa. A total of 275 student members attended the school which was of two weeks duration. Lectures and demonstrations relating to practical aspects of welding were included in the first week, while the second week was devoted to more specialised subjects such as the metallurgy and physics of welding, testing and inspection, design and analysis and experiment, etc.

Altogether, over 70 lectures were given by a large group of scientists and engineers from industry and the universities, and from research organisations, including the B.W.R.A. A number of member firms of the Association provided equipment to demonstrate the latest advances in welding technique and processes, and also the application of modern methods of non-destructive testing.

As in 1951, the School was eminently successful and many requests for a similar training course next year have been received by the Association. Consideration is, therefore, being given to holding a third school in the spring of 1953 and further announcements about this will be made in due course.

The International Machine Tool Exhibition

New Developments on Show at Olympia

The importance of machine tools to this country is twofold; in the first place, they are essential aids to increased productivity, and, secondly, they have an intrinsic value as direct exports. This year's International Machine Tool Exhibition, the first to be held at Olympia for four years, promises to be up to the standard of its predecessors, and in the following pages is presented a brief account of some of the exhibits of interest in the metallurgical field.

FOR the first time since 1948, the Machine Tool Trades Association is holding an International Machine Tool Exhibition at Olympia. The exhibition, which opened on September 17th, will be open each week day, from 9-30 a.m. to 6 p.m., until Saturday, October 4th, and the public will be admitted at a charge of 3s. 6d. per head. Apart from Great Britain, countries represented will include Belgium, France, Germany, Italy, Scandinavia, Switzerland and the U.S.A., and the international note of the exhibition will be stressed by the attendance of visitors from every machine tool-using country in the world.

Special amenities at Olympia include a rest lounge, which occupies an enclosed area adjoining the escalators north of the well of the Second Floor, Empire Hall, where visitors may rest and relax in comfort. A service centre adjoining the lounge accommodates an information bureau, interpreters, banking facilities, direct overseas cable and telephone communications, stenographer's bureau, a florist, photographic service and theatre ticket office.

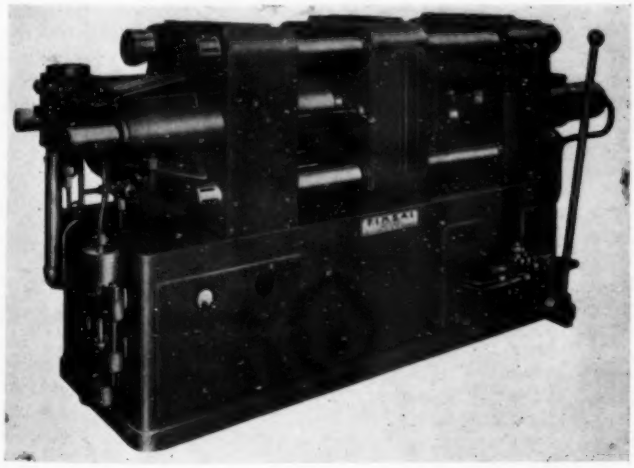
The exhibition covers some half-million square feet of floor space and the wide range of exhibits includes machine tools, engineers' small tools, gauges, measuring equipment, testing equipment, presses and power hammers, heat-treatment plant and wood-working machinery. In the limited space at our disposal, it would be difficult to list all the items on show, and to give even a short description of each would be impossible. In the following brief account of the exhibits, attention is, therefore, confined to equipment used in the metal and engineering industries for melting, casting, hot and cold working, heat treatment and testing, together with such cutting and grinding machines as have been specially developed for the metal industries.

Melting

For the first time at an exhibition of this kind, BIRLEC, LTD. (Stands 84 and 85) are showing a self-contained laboratory-type furnace, which attains a temperature of up to 2,000° C., in which such operations as melting, degassing, heat treatment and sintering can be carried out under a vacuum of 1 micron or less, or under controlled atmosphere conditions. All controls are outside the unit and it is possible to add to the melt, stir it, or pour it without destroying the vacuum or spoiling the atmosphere. Further particulars of this equipment will be found in our Recent Developments' Section on page 154.

Equipment for melting metals such as lead, tin, solder, bearing metals and zinc base alloys is to be found on Stand 97 (FUNDITOR, LTD). This includes 3-cwt. and 7-cwt. electric melting furnaces, a Coulthard electrically heated diecasting pot, and a solder pot for general industrial use.

Among the furnaces shown by BRAYSHAW FURNACES AND TOOLS, LTD. (Stands 91 and 92) are an electrically heated pot-type furnace for melting soft metals, such as tin, lead and white metals, and two small laboratory bench-type melting furnaces. One of the latter furnaces is of the gas and air blast type used for melting small quantities of metal at temperatures up to 1,250° C., and the other a natural draught type generally employed for assay work.

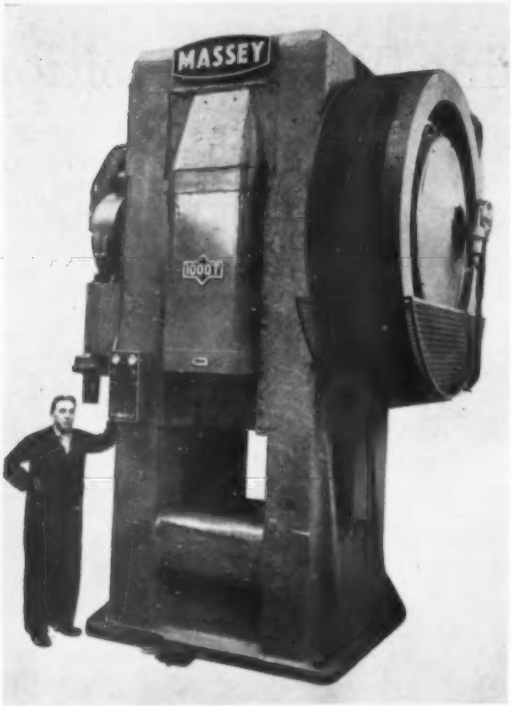


Courtesy of E. P. Barrus (Concessionaires), Ltd.

F.I.M.S.A.I. Model PF.4,000 diecasting machine.

Casting

Of the exhibits on Stand 18 [E. P. BARRUS (CONCESSIONAIRES), LTD.] there are two of particular interest in the metallurgical field. They are F.I.M.S.A.I. (Fabbrica Italiana Macchine Stampaggio Ad Iniezione) die-casting machines for non-ferrous metals. The Model 1,000 has a nominal capacity for copper and zinc alloys of 1,000 g. (about 2¼ lb.) and for aluminium alloys of 300 g. (about 10 oz.), whilst the corresponding figures for Model 4,000 are four times as great. Large area is associated with the mould carrying plates, and a large plate opening permits of deep work being handled. The mould closing pressure and the injection pressure are both high, and with the high output pump and the large high pressure accumulators, fast operational speeds can be obtained without significant pressure drop.



Courtesy of B. & S. Massey, Ltd.

Massey 1,000 ton high speed forging press.

Hammers and Presses for Hot and Cold Working

B. & S. Massey, Ltd. (Stand 69) are showing two recent additions to their range of forging and drop-forging plant. The first is a 250-ton high-speed forging press, the smallest of a range designed for the rapid production of drop forgings or pressings, and fitted with a patent control system which provides alternative methods of operation to suit different types of forgings. It is hoped to show this machine at work in conjunction with a Birlec induction heating unit. The other new machine is a 10-cwt. Marathon drop hammer which has been specially designed to meet the conditions which prevail when mass-production methods are used and where intricate forgings of an exacting nature are made. The remaining exhibits, which are of established design, include a double-acting drop hammer, electro-pneumatic forging hammers, and a solid-frame clipping press, together with models of other equipment manufactured by the Company.

Publicly shown for the first time on Stand 70 (Wilkins & Mitchell, Ltd.), the Forgemaster N forging press is representative of a new range of forging presses, with capacities from 250 to 3,000 tons, designed and built to an all British specification. As such, they will compete favourably in world markets as a dollar saver. The design of the four-rod bed area enables the presses to dummy, set and trim in one operation in conjunction with a drop handle. Used in conjunction with the Forgemaster on the stand is a 100-ton stripping and setting press designed for multi-tool set-ups, with two sets of wedges for independent tool adjustment. Also displayed are a 100-ton hot brass stamping press and a 150-ton blanking and drawing press.

A Beche & Grohs pneumatic die-forming hammer with a tup weight of 200 kg. is featured on the Burton Griffiths Stands (77 and 78). The pressure on the tup is proportional to the pressure on the foot control pedal, which permits very accurate control and considerably increases the scope of these machines.

E. W. Bliss (England), Ltd. are showing a number of presses on Stand 56. For the production of large quantities of stampings requiring comparatively short strokes, there is a No. 620 high production press, whilst a No. 820 strip feed press with a single curling attachment is capable of producing end stampings for cams at the rate of 150 per minute. The remaining press exhibit is a 55-ton flywheel-type inclinable power press of 4 in. standard stroke.

The sole world selling agents for the range of presses incorporating the Hi-Ton ram type pump unit—Drummond-Asquith (Sales), Ltd. (Stand 165)—are showing a representative of the range. Up to 100-ton capacity, they are pedestal-type machines with power return to the ram, and the extremely sensitive control permits holding the stroke, inching, or returning the ram at any part of the stroke. Machines up to 250 tons capacity have been built with multiple rams, and a further development meets the need for multi-station machines.

An important feature of the 300-ton Hymulti double action press shown by Weatherley Oilgear, Ltd. (Stands 71 and 228), is the independent four-point pressure blank holder which is of special value in work on unbalanced draws. This press is powered by an Oilgear radial-piston, variable-displacement pump, and maximum pressure is available for coining at the bottom of the stroke. For the accurate straightening of parts between centres, or on vee-blocks, there is a 50-ton gooseneck straightening press with variable ram speed and sensitive control. A further press exhibited on this stand is a 60-ton capacity horn press.

Exhibits being shown on Stand 38 (Vickers-Armstrong, Ltd.) include a British Clearing double-action hydraulic press, which can be used as a single-action press developing 225 tons, and a working scale model of a triple-action press made in the Elswick Works Apprentice School. There is also a display of British-built press shop equipment such as precision slide feeds, stock straighteners, stock reels, coil cradles, scrap cutters and multi-stops. The use of such equipment reduces manual handling of material, and converts almost any ordinary press into an automatic machine.

Of particular interest on Stand 75B (Pearson Phillips, Ltd.) is the Schuler automatic transfer press, with 14 tool stations, which will carry out deep drawing work, a field in which the great advantages offered by following one operation by another without an appreciable time interval are particularly well-demonstrated. In order to overcome the overheating of the tools resulting from long continuous runs, a system of internal water cooling of the tool stations is incorporated. Other press exhibits include a high-speed, automatic strip-feed press, a double-sided high-speed press, an inclinable power press and a scrap-baling press, whilst equipment for the manufacture of collapsible tubes is represented by a machine for one of the final stages in this process—i.e., for printing.

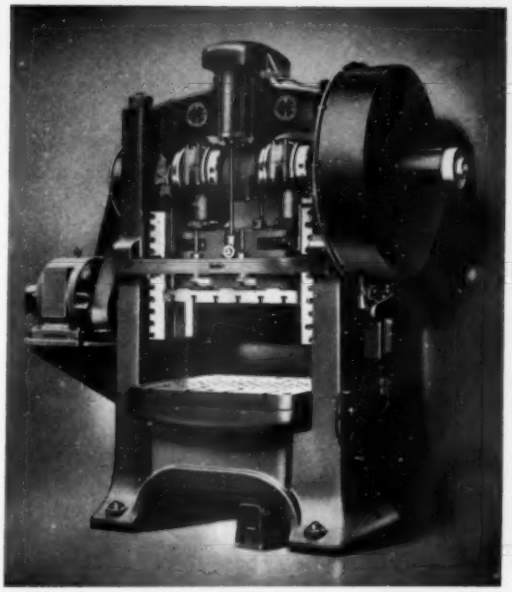
A varied range of press equipment is being shown on Stand 73 by Hordern, Mason & Edwards, Ltd. Of

the inclinable ungeared presses, a 40-ton model is suitable for blanking, piercing, forming, etc., whilst a 12-ton press of this type is designed for high rates of output from coiled strip metals. The remaining presses include a 100-ton geared variable stroke press ; a 150-ton geared double-crank single-action variable-stroke press ; a 200-ton geared double-sided crank press ; and a double-sided double-action receding-table drawing press.

An item of particular interest on the Stand of HUMPHRIS & SONS, LTD. (163) is a 20-ton inclinable crank press, fitted with a double roll feed. Operating at 100 strokes per minute, strip or coiled material up to 9 in. wide can be fed with infinitely variable increments up to 6 in. A new standard dial feed press of 10 ton capacity is also on show. To allow for a variety of conditions, its speed is variable between 50 and 80 strokes per minute. Further new developments to be seen are two self-centring coil stands, designed to assist in the handling of coiled stock for roll-feed presses.

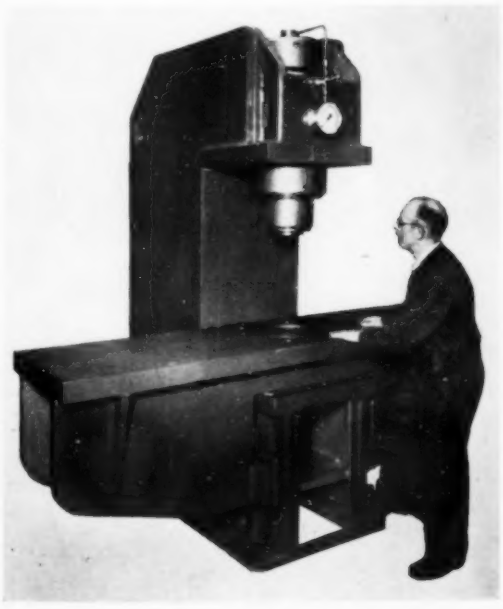
The National Maxipres forging machine used in the production of forgings for the automobile industry and of turbine blades as used in jet engines, is shown in the form of a working model on Stand 76 (BUCK & HICKMAN, LTD.), where the actual machines exhibited include a National No. 2 Reducerol, designed to pre-form forging blanks in a wide variety of shapes, lengths and sizes for finish forging, and a Rhodes hydraulic press incorporating special features permitting two draws to be made on a component at one operation.

The 12½ ton E.H.J. unit press shown on Stand 14 [E. H. JONES (MACHINE TOOLS), LTD.], is built to a design embodying machine tool mechanical efficiency and flexibility of frame style and dimension. The construction of the press from self-contained units enables the manufacturers to incorporate more easily progressive modifications. On the same stand are two C.V.A. dieing presses of 25 and 50 tons capacity which have been scientifically designed to meet modern high-speed production and possess a number of interesting features, including easy accessibility to the work area, low centre of gravity—tending to eliminate vibration, silent pinion drive to high-tensile iron flywheel, and pressure lubrication to all moving parts.



Courtesy of Hordern, Mason & Edwards, Ltd.

Type D.C.P.5 geared double-crank single-action press.



Courtesy of Drummond-Asquith (Sales), Ltd.

Hi-Ton pedestal type hydraulic press.

Recent years have seen a considerable increase in the interest shown in the impact extrusion process. A Herlan press for the production of collapsible tubes and similar hollow-ware from lead, tin, tin-coated lead, zinc, aluminium and other non-ferrous metals by this process is to be seen on Stands 6 and 7 (WICKMAN, LTD.). An attached feeding arrangement provides for automatic feeding of the blanks through the magazine and thence into the die. After forming, the extruded component is stripped and passed to a conveyor by an indexing attachment.

Other hydraulic and mechanical presses are shown on Stands 47 and 48, occupied by members of the 600 GROUP OF COMPANIES.

Other Metal Working Equipment

One of the new machines on Stand 114 (OLIVER MACHINERY CO., LTD.) is a stamping trimmer designed for trimming flash from pressings and stampings without the need for expensive trimming dies. It can also be used for beading and forming the pressings. Other new exhibits include a machine for cold flanging up to a maximum capacity of ⅝ in. mild steel, a range of rotary shears for sheet metal, a universal box and pan bending brake and a Sinton flange-ring bending machine for rolling angles, tees, channels and flats. Also on show are a number of machines for finishing the edges of sheet metal products.

THOS. W. WARD, LTD., on Stand 40, are showing an Eldair power press brake of capacity 8 ft. × ¼ in. mild steel. It has a multi-plate clutch and self-releasing band brake to permit the ram to be inched down to the work, and has power-operated top beam adjustment.

Courtesy of Thos. W. Ward, Ltd.

Eldair overcrank guillotine shearing machine.

The ram is of good depth for non-deflection and is adjusted by motor through compound gearing. Also to be seen on this stand is an Eldair overcrank guillotine shearing machine which has a capacity of 8 ft. × ¼ in. mild steel, and is designed to make 45 strokes per minute, to permit continuous operation, if required. All working and moving parts are shrouded at the front and vision of the plate for line shearing is afforded by a Perspex screen running the full length of the machine.

Three Drabert machines are being shown by Rockwell Machine Tool Co., Ltd. (Stands 49, 50, 211, 229B, 232, 233 and 237). One of them is a multi-purpose nibbling machine suitable for cutting, beading, flanging and riveting, whilst the others are guillotine shearing machines with capacities of 8 ft. × ¼ in. and 6 ft. × ¼ in., respectively. The larger guillotine has hydraulically operated pressure pads whilst those on the 6 ft. machine are mechanically operated.

Besides the presses to be seen on Stand 38 (Vickers-Armstrong, Ltd.) there is a British Clearing hydraulic press brake of 150 tons capacity. It is one of the latest additions to the British Clearing range and is 6 ft. 6 in. between uprights. A 50-ton capacity press brake with horn extension on the left-hand side for box forming work is also on view.

A Spiertz guillotine shear, representative of a range capable of cutting steel plate up to 1 in. thick and 14 ft. long can be seen on Stand 75B (Pearson Phillips, Ltd.), along with two Schuler notching machines, for such operations as notching rotor and stator segments, and a Clemens and Vogl semi-automatic seaming machine for irregular cans.

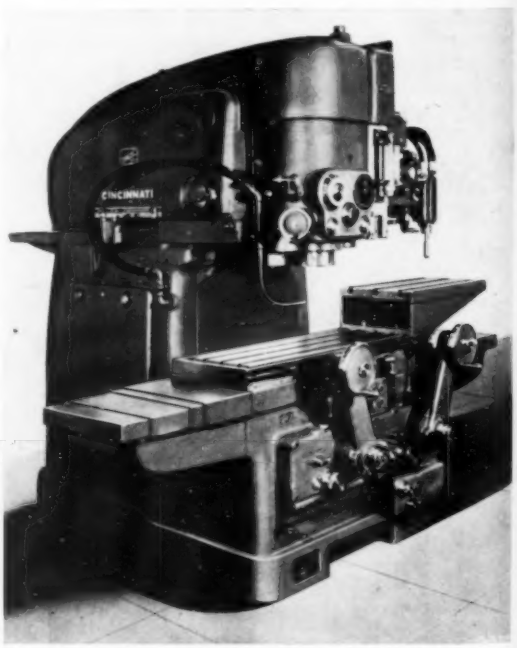
A recent addition to the Rushworth range of sheet metal working machinery to be seen on Stand 75A (Morrison, Marshall & Hill, Ltd.) is a precision guillotine of the worm-geared undercrank type. Made in the following capacities—4 ft. × ⅛ in.; 6 ft. × ⅛ in.; and 8 ft. × ⅛ in. mild steel—these machines possess a number of interesting mechanical features designed to ensure that continuous and accurate service can be given under the most arduous conditions. Nor is safety overlooked: the measures adopted include a foolproof non-repeat device. Other established machines to be seen are an 8 ft. × ½ in. guillotine and a Rushworth 50/8 press brake.

The Hufford A.10 stretch-wrap forming machine shown on Stands 6 and 7 (Wickman, Ltd.) will produce components of complex character, e.g. varying curvature, varying angle or a combination of both, reverse form, double curvature convex and saddle backs, etc. All formable materials such as aluminium and its alloys, mild steel, stainless steel, etc., can be handled with equal facility and parts of uniform consistency are produced. The Hufford range includes five extrusion types, of which the A.10 is one, and four sheet types to handle material up to 378 in. in length and 72 in. in width. Also to be seen on the same stand is a Pines No. 1 tube and rod bending machine designed for high-speed bending operations on tubes, rods and extruded sections, with a maximum tube capacity of 7½ in. diameter by ½ in. wall thickness. On Stand 8 a Hilmor MD.2a tube bending machine and a Hilmor hydraulic portable tube bending machine are on show.

The gang slitting machine featured by E. W. Bliss (England), Ltd. on Stand 56 is designed to slit tinplate sheets up to a maximum thickness of 0·025 in. and is widely used in tin box manufacture. Owing to the ease of resetting the machine, it is specially suitable for

Courtesy of Wickman, Ltd.

Hufford A10 stretch-wrap forming machine.



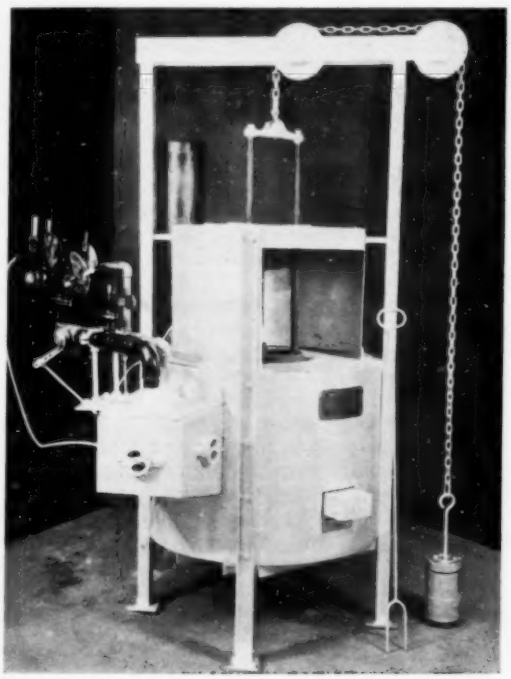
Courtesy of Cincinnati Milling Machines, Ltd.

16 in. vertical Hydro-Tel.

installation in can-making lines which are frequently changed over to make several different sizes of container.

HEENAN & FROUDE, LTD. are exhibiting on Stand 27 representatives from their range of automatic wire and strip forming machines. These machines are designed for the production of an almost unlimited range of wire and strip parts from coiled stock in a single pass through the machine. The design permits many parts to be produced in pairs or even four together, small parts like electrical components being produced at a rate of over 28,000 an hour. Four sizes of wire and strip-forming machines are shown, together with a chain-making machine and an automatic for the production of paper clips.

Two Weybridge gang slitters, for material 30 in. × 22 s.w.g. and 36 in. × 8 s.w.g., respectively, are on view on Stand 48 (600 GROUP OF COMPANIES), together with a Coborn double-ended punch and shear, while the same Group, on Stand 47, are exhibiting two Hilger's power-



Courtesy of Brayshaw Furnaces & Tools, Ltd.

Gas-fired salt bath furnace.

operated pipe bending machines with capacities of 8½ in. diameter × $\frac{5}{64}$ in. and 1$\frac{7}{64}$ in. diameter × $\frac{5}{64}$ in. A further metal-working exhibit on this stand is a Bofors treble-blow cold heading machine of ½ in. diameter capacity.

In addition to the presses exhibited by BUCK & HICKMAN there is on Stand 76 a Rhode's hydraulic shearing machine.

Machines for Die Production and Pattern Making

Of the wide range of milling machines exhibited on Stand 74 by CINCINNATI MILLING MACHINES, LTD., there are two types of particular interest in the metallurgical field in view of their use in the production of dies. The 8 × 18 tool and die milling machines possess an unusual

Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Wild-Barfield universal high-frequency work-head fitted with melting crucible.

degree of versatility which permits a wide range of secondary operations (such as drilling, reaming, boring, angular cutting and slotting) to be performed at one setting within an area of 8 in. × 18 in. The cross range can be extended to 14 in. by a ram type sliding movement of the head. The 16 in. × 30 in. vertical Hydro-Tel offers all the features needed by the practical die-maker for automatic scanning of moulds and dies. Hydraulically operated, it ensures smooth and accurate duplication from templates or full masters. This machine is engaged in sinking a crankshaft die and profiling the name "Cincinnati." A Monoset cutter and tool grinder, which makes as well as sharpens cutters, maintains the cutters used on these machines.

The Hayes Diemaster, a British-built universal die and mould milling machine shown by DOWDING & DOLL, LTD. (Stands 2A and 9) is an accurate adaptable machine for the production of small die moulds and tools. Particular attention has been paid to the balance of all moving parts and the machine has finger light control under all working conditions. Other machines used in die production include a range of Swiss Rigid millers, two of them of the hydro copying type.

BURTON GRIFFITHS, LTD. (Stands 77 and 78) are exhibiting a Deckel universal pantograph die-sinking machine which covers two and three-dimensional duplication at a 1 : 1 ratio as well as reducing or enlarging work. Masters and patterns can be made from drawings or sample parts and dies produced from a single set-up. Primarily intended for the economical production by the copying method of tools for press work, such as dies, moulds, punches, etc., a Heyligenstädt automatic copy milling machine can also be seen on this stand.

On the WICKMAN Stand (6 and 7), three machines from the Fritz Kopp range of automatic copy milling machines are on view. They include a high production circular table model, a keyway, slot, spline and profile milling

Courtesy of Radio Heaters, Ltd.

30 kW. Radyne induction heating unit.

machine, and a fully-hydraulic single-spindle three-dimensional co-ordinate milling machine for the production of plane curves and three dimensional curves. On the same stand is the Wickman profile grinding machine for the production of intricate form tools, die segments, gauges, etc., to a high degree of accuracy.

Nassovia die sinking machines are being exhibited by DRUMMOND-ASQUITH (SALES), LTD. (Stands 11, 12, 13 and 165), and the "Copyrite" copying equipment for milling machines is shown for the first time by S. N. BRIDGES & CO., LTD. on Stand 4, where it is being used for the production of moulds for gas turbine blades. THE ROCKWELL MACHINE TOOL CO., LTD. are showing on one of their stands the Delisle & Ziegele universal tool and die milling machine.

WADKIN, LTD., woodworking machinery engineers, are exhibiting a range of 15 of their latest types of machines on Stand 79. Outstanding among them is the Type W.X. universal pattern miller, in spite of the fact that it is well known in pattern shops, because recent major design improvements have been made in the spindle and drive.

Heat Treatment Plant

The inclusion of heat treatment plant in a machine tool exhibition is now a well recognised practice; not only are machine tool users and machine tool manufacturers dependent on accurate heat treatment for many of their production processes, but also the increasing mechanisation of charge handling in furnaces gives these units many machine tool characteristics. The exhibits on Stand 84 and 85 have been chosen by BIRLEC for these qualities, although limitations of size has also been a factor. They include a 20 kW. shaker hearth furnace, a 250 c.f.h. atmosphere generator, a high-frequency induction gear hardening machine, and a 6 kW. spark-gap convertor. The compressed air supply to the shaker hearth furnace is dried by passing through a Birlec Lectrodryer.

Apart from the size of many of the items, the wide range of the equipment made by THE INCANDESCENT HEAT GROUP presents a formidable display problem. On Stand 30, recourse is had to scale models (some of them working models) representative of the products of of the individual companies of the Group. These include gas-fired and electric heat-treatment furnaces, ancillary heat-treatment plant, electric arc furnaces for steel melting, cupolas, gas and oil burners, atmosphere generators, vitreous enamelling equipment and heat-resisting alloy castings.

Attention is drawn to the latest developments in three important heat-treatment processes on Stands 89 and 90 (WILD-BARFIELD ELECTRIC FURNACES, LTD.). They are: gas carburising with prepared town's gas—the process being traced from the entry of the gas into the preparation unit to the gas carburising furnace; carbo-nitriding; and induction heating. The importance of the work-handling jig in induction heating has led Wild-Barfield to design a universal workhead to which can be fitted by "plugging in" any number of handling jigs, which can incorporate automatic and semi-automatic devices for loading and unloading. A range of these jigs is on view, together with a selection of photographs of special purpose machines.

The BRAYSHAW FURNACE COMPANY'S exhibits on Stand 91 and 92 are devoted entirely to a selection of standard industrial heat-treatment furnaces and a selection of engineer's small tools. The furnaces on show, five of them in operation, include a gas and air blast oven furnace of the recuperative type, and a natural draught oven furnace—both suitable for general heat treatment at 650°–1,000° C.; two sizes of twin-chambered high-speed steel treatment furnaces; an electrically heated high-speed steel furnace with furnace doorway gas atmosphere provision; a salt-bath furnace; and an air-recirculation tempering furnace. Larger furnaces will be featured in a photographic display.

Three types of high-frequency induction heating equipment are shown on Stand 161 by DELAPENA & SONS, LTD. All have been designed as robust production tools and the respective powers are 2½, 6 and 15 kW. An interesting feature is the separate remotely controlled applicator which enables the generator to be located in some position where it does not take up valuable floor space. A feature of the 15 kW. model is the use of oil cooling in the remote applicator, which allows very compact construction.

An interesting item in the display of high-frequency induction heating equipment on Stand 28 (RADIO HEATERS, LTD.) is the new 30 kW. Radyne unit, with its single air-blast cooled oscillator valve. Variable output is obtained by varying the coupling between primary and secondary of the H.F. output transformer, so that correct matching between the oscillator valve and the load being heated is obtained under all conditions. Other exhibits include a small 1 kW. unit specially designed so that it may be incorporated as an integral part of larger machines or accommodated beneath the workshop bench.

An item of some interest for heat-treatment engineers is a Gleason No. 26 quenching press, which is a new design of press for holding and quenching heat-treated gears and other components so that they may be hardened without distortion. It is on view on Stand 76 (BUCK & HICKMAN, LTD.).

Saws, Cutting-Off Machines and Grinding Equipment

A new range of multi-speed metal-cutting band-sawing machines is being produced by METALCLAD, LTD.

for whom GEORGE COHEN, SONS & CO., LTD. are acting as agents. Made in two sizes, 24 in. and 30 in., each size having a choice of three speed ranges with four speeds per range, these machines have been designed to cut a wide variety of materials much more quickly than would be possible by other means. The greatest time saving is, perhaps, in the cutting of non-ferrous metals—particularly aluminium alloys. Representative models can be seen on Stand 115.

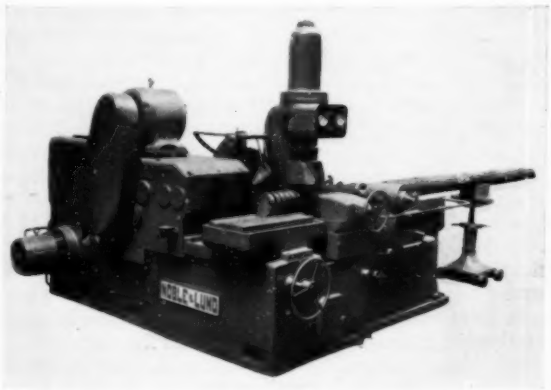
With the 22 in. Fluifeed automatic cold circular sawing machine shown by NOBLE & LUND, LTD. on Stand 29, the cutting up of steel bar stock is, once the machine has been set up, completely automatic until the sawing of the last bar, when the machine stops. Among the new features of this machine are the automatic lubrication of the bearings by means of a plunger pump; a spiral chip conveyor which conveys the cuttings to the back of the machine during operation; and built-in control gear.

A Crypto-Atlas electric metal bandsawing machine is being shown by FIRTH BROWN TOOLS, LTD. on Stand 204.

The new C.B. Minor metal sawing machine featured on Stand 22 by CLIFTON & BAIRD, LTD. is designed to meet the need for economical cutting of small sections, and the work-table fixture can accommodate solid steel bars, squares, slabs, rails and rolled steel sections. Three cutting speeds are provided, suitable for cutting the normal classes of steel, whilst special speeds can be provided to suit non-ferrous metals and other particular conditions. An angle-faced vertical vice and a swivelling horizontal vice can be fitted to deal with all angle cuts up to 45°.

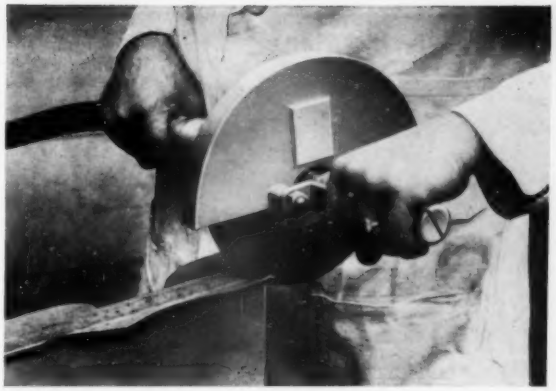
The Mitre cold sawing machine developed by CHARLES WICKSTEED & CO. (1920), LTD. for the rapid cutting of metal window frame sections and similar work is to be seen on Stand 2B. The two 16 in. diameter segmental blades are set at the required angle of 45° for taking opposite mitring cuts and various sections can be handled for standard door and window frames. Also exhibited is a Wicksteed hydraulic control hacksawing machine.

The 12 in. power hacksawing machine shown on Stand 107 by KERRY'S (GREAT BRITAIN), LTD., is belt-driven, by a foot-mounted motor housed in the base, through a three-speed gearbox. The blade is hydraulically fed and is adjusted by a graduated feed dial which, used in conjunction with the three-speed gearbox, enables



Courtesy of Noble & Lund, Ltd.

22 in. automatic Fluifeed cold circular sawing machine.



Courtesy of Flextol Engineering Co., Ltd.

Flextol cutting-off attachment in operation.

the quick selection of correct speeds and feeds for the type of material being cut.

"Service to Industry" is the theme of Stand 154 where THE CARBORUNDUM CO., LTD., in addition to showing certain new developments in the abrasive field, are exhibiting examples of the way in which proper selection of grinding wheels can reduce the cost of grinding to remarkably low figures. They include such varied applications as spindles, needles, bar-stock, forgings, tiles and piston rings.

Amidst a wide range of grinding wheels and stones on Stand 183 (UNIVERSAL GRINDING WHEEL CO., LTD.), a $\frac{3}{4}$-ton vitrified wheel contrasts strangely with the tiny $\frac{1}{4}$ in. diameter wheel placed in its bore. A new development is shown in a series of Uni-lastic wheels which are resin bonded and fabric reinforced. They range from 6 in. to 20 in. in diameter, the larger ones being used in foundries for removing risers from ferrous and non-ferrous castings, whilst the smaller ones are used on hand grinders for notching, as well as for cutting away and smoothing welds, descaling, deburring, etc.

NORTON GRINDING WHEEL CO., LTD. on Stand 187, are also showing newly developed reinforced wheels which are intended for use on right-angle portable grinding or sanding machines. Several layers of strong fabric are moulded into the wheels to provide strength, and the file-like finish on the cutting surface gives a remarkably fast, clean cutting action without loading. A further display features the Behr-Manning range of coated abrasives whose manufacture in Northern Ireland is expected to begin early in 1953.

MINNESOTA MINING & MANUFACTURING CO., LTD., manufacturers of surface coated abrasives, are showing their latest abrasive products on Stand 177, together with the latest types of polishing and grinding machines for use in conjunction with them. Of special interest is the Taylor portable belt grinding and polishing machine which provides a speedy and economical means of removing welds, burrs, flashes, etc., from heavy castings or fabrications which are too heavy or too large to be efficiently handled by an operator.

A full range of flexible-shaft power-driven hand tools for such operations as grinding, sanding, rotary filing, milling, polishing and buffing is displayed on Stand 155 by FLEXTOL ENGINEERING CO., LTD. One of the latest developments on show is a high-speed "cutting off" device for removing runners and risers from ferrous and

Courtesy of The Carborundum Co. Ltd.

A View of the Carborundum stand.

Courtesy of Edward G. Herbert, Ltd.

Olsen 120/ft. lb. impact testing machine.

non-ferrous castings, and for trimming pressings. A further machine in the display has been designed for operating high-speed cutting and grinding hub discs, for which a new handpiece provides a speed of 7,500 r.p.m by means of gearing. The discs may be used for cutting or grinding according to whether the edge or surface is used.

The range of high-speed grinders shown by CENTRAL TOOL & EQUIPMENT CO., LTD. on Stand 110A includes a 20,000 r.p.m. portable model widely used for die grinding; an 18,000 r.p.m. grinder which has about double the horse power; and a super high-speed grinder running on a high cycle three-phase supply at 40,000 r.p.m. for use with tungsten carbide burrs.

Testing Machines

A number of Olsen mechanical testing machines made by EDWARD G. HERBERT, LTD. are shown by that Company on Stand 25. The 60,000-lb. hydraulic universal testing machine has many advanced features in its design and construction. Among these is the direct connected gear pump with its simplified arrangement of piping and an absence of jarring pulsations during loading. The 120 ft.-lb. impact testing machine shown has a Change-o-Matic head by the use of which a choice of Izod, Charpy and tension impact tests can be made by the twist of a wrench. Other exhibits include a ductility testing machine, a 10,000 in.-lb. torsion testing machine, and two Brinell hardness testing machines—one motor driven.

A Model UHW.6 Losenhausenwerk universal fatigue testing machine being shown by WICKMAN, LTD. (Stands 6 and 7) is designed for endurance tests on material specimens for tensile, compressive and bending stresses, under undulating load, plus-minus oscillating and alternating load at frequencies up to 3,000 oscillations per minute: static tests may also be carried out on it. The range of these hydraulically operated machines extends from 20 to 200 tons static load, and from 10 to 100 tons dynamic load, and includes machines suitable for tests on structures as well as on test pieces. For fatigue tests at high temperature, the machine may be fitted with an air-bath furnace suitable for accommodating specimens of 2 in. gauge length. Another Losenhausenwerk machine on this stand is a pendulum type impact testing machine—one of three available models with striking energies of 30 or 15 m. kg., 75 or 40 m. kg. and 250 m. kg., respectively.

Included in the selection of hardness testing machines to be seen on Stand 20, W. & T. AVERY, LTD. are showing their new motor-operated production Brinell testing machines. This is a direct-reading instrument, the difference in depth of the impression when a light load and then the full load are successively applied being measured by a dial gauge. Further details of this machine are given in our Recent Developments' Section on page 153.

Other hardness testing machines will be seen on Stand 204, where FIRTH-BROWN TOOLS, LTD. are showing three forms of the Firth Hardometer—the fixed-load type, the variable-load type and the new double-pillar type; and on the DRUMMOND-ASQUITH (SALES), LTD. stand where the Wolpert hardness testing machines are featured.

A 2-ton creep-testing machine, including extensometer and control panel, as used at the N.P.L. and in other leading laboratories, is being shown by S. N. BRIDGES & CO., LTD. on Stand 4. It can be used at temperatures up to 900° C. and tensile loads up to 5,000 lb.

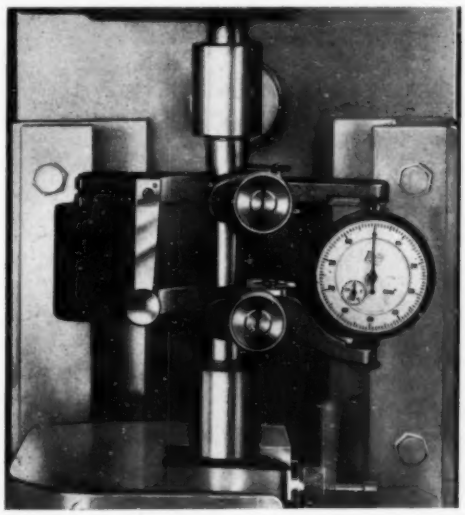
The display of J. E. BATY & CO., LTD. on Stand 168, includes a number of items of measuring equipment for various purposes. Of particular interest is the Lindley extensometer, designed for the speedy and accurate determination of proof stress. There are two models, one up to $\frac{5}{8}$ in. diameter or thickness, and up to $\frac{3}{4}$ in. width, and the other from $\frac{1}{2}$ to $1\frac{1}{2}$ in. diameter and $1\frac{1}{2}$ in. square. Both have a gauge length of 2 in. and a magnification factor of 1250 : 1. The extension of the material under test is magnified in a ratio of 2 : 1 by a single lever, and thereafter measured and indicated by a dial gauge graduated in ten-thousandths of an inch.

Miscellaneous

EDGAR ALLEN & CO., LTD. on Stand 230 are showing a range of small tools, permanent magnets, die steels and

special tool steels. The die steel display shows a range of steels for dies working on aluminium, copper-base alloys, etc., together with completed dies showing high accuracy of finish. Interesting items in the small tools section include roll turners' tools in 10–12% cobalt steel with a minimum Rockwell hardness of C.65, form tools in the same material, high-speed steel tools and Athyweld deposit-welded tools. A selection of permanent magnets is linked photographically with the instruments in which they are used.

Stand No. 190 is mainly concerned with the extensive FLETCHER MILLER range of cutting fluids and machine tool lubricants, several grades of which can be seen in operation on machine tool makers' stands. Other products on show include alkaline degreasing compounds and cleaners ; rust removers and preventatives, including the usual dewatering fluids for the protection of ferrous surfaces ; drawing compounds for press working, and wire, bar and tube drawing lubricants in liquid or solid



Courtesy of J. E. Baty & Co., Ltd.

Lindley extensometer in use on a bar specimen.

form ; and a universal easing oil. Of particular interest are the carburising compounds, for either closed box or open hearth carburising, and the range of quenching and tempering oils.

A selection of Spuncast Holfos bronze cored bars, machined bearing bushes and similar components will be featured on Stand 118, by JOHN HOLROYD & CO., LTD., together with bronze gear blanks and other castings in Super Holfos. The display will also include a selection of worm, spur, spiral, bevel and helical gears, an ending and centring machine, two powder metallurgy presses and a woodworkers' tool grinder.

METROPOLITAN-VICKERS' products for the machine tool industry cover a wide range of motors and control gear and visitors will be interested to see such equipment fitted to various types of machine tools on the stands of many well-known manufacturers. On Stand 262, a staff of qualified engineers is in attendance throughout the period of the exhibition, and is available to discuss with visitors electrical problems relating to machine tools.

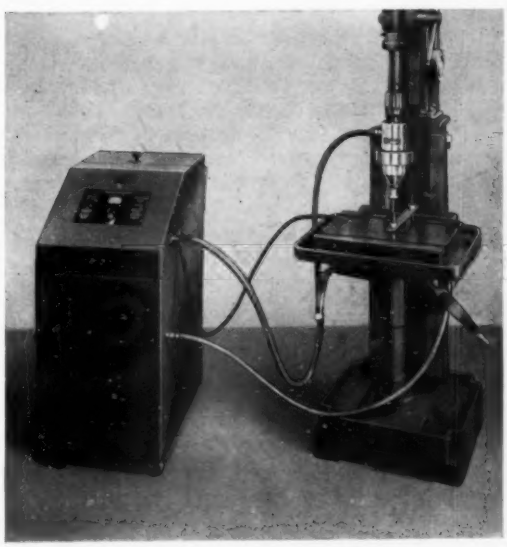
Besides the Hardometer testing machines referred to earlier, FIRTH-BROWN TOOLS, LTD. are showing, on Stand 204, a twist drill point sharpening machine ; a sharpening machine for circular saws with Mitia carbide tipped teeth ; a Crypto-Atlas electric metal band-sawing machine ; and a comprehensive range of engineers' cutting tools of all types.

STEIN & ATKINSON, LTD., on Stand 174, are exhibiting their British-made Vickers-Detroit oil hydraulic equipment. The range includes vane pumps and valves for regulation, control, reversal or sequential operation. The display comprises a number of actual units and a range of pumps and valves sectioned so that the internal features can be readily demonstrated.

The main exhibit on Stand 207 (W. T. FLATHER, LTD.) is a machining demonstration on their Nylkut super free-cutting steel, in which air release adaptors are being machined from 0·782 in. hexagon bright bar on an Index 24 automatic. A number of components for machine tools, machined from the Flather range of steels will also be displayed.

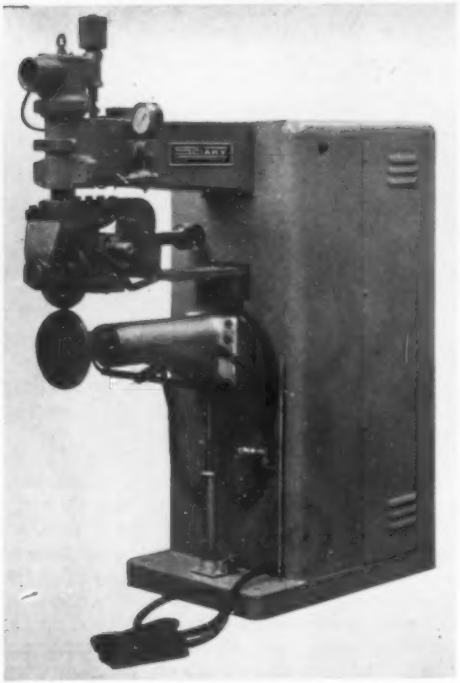
Three ways of testing lubricants for cutting tools are being demonstrated by SHELL-MEX & B.P., LTD. on Stand 205. The four-ball tester is used in the assessment of the extreme pressure properties of oils, whilst the Institute of Petroleum corrosion test is designed for cutting oil emulsions. Steel millings are placed on the four quarters of a cleaned cast iron plate and a measured amount of the emulsion is poured on each quarter. After 24 hours, the millings are removed and an estimate of the corrosion made on the basis of area attacked and intensity of corrosion. The third test shows the differences between cutting oils in staining yellow metals.

Amongst the interesting exhibits of resistance welding plant on Stand 86 (SCIAKY ELECTRIC WELDING MACHINES, LTD.) is a heavy duty projection welding machine rated at 400 kVA. which is claimed to have three times the efficiency of the conventional type. This machine can be adapted for twin projection welding by

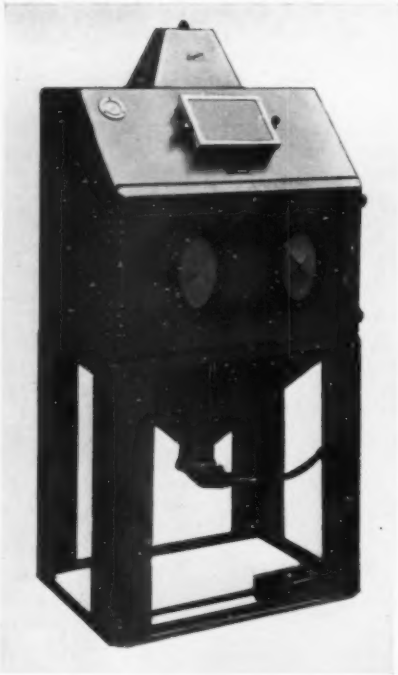


Courtesy of Gaston E. Marbaix, Ltd.

Model 51 Disintegrator.



Courtesy of Sciaky Electric Welding Machines, Ltd.
Seam welding machine.



Courtesy of Guyson Industrial Equipment, Ltd.
Model 400/15 shotblast cabinet.

the addition of a second cylinder assembly. Also on view is the latest development in portable spot welding machines, which is air-operated with fully automatic control, and is capable of welding two equal thicknesses of $\frac{1}{8}$ in. mild steel sheet. Other exhibits include seam welders, spot and stitch welders and a bench machine for welding delicate assemblies. Finally, there is a 75 kVA machine for the simultaneous completion of a large number of welds in wire mesh.

An indication of the variety of methods applied to obtain permanent marking on materials and components can be obtained by a visit to Stand 97, where FUNDITOR, LTD. have on show a range of machines for this purpose. These include manually operated, pneumatically operated and hydraulically operated equipment, together with Sandjet markers and blocking presses.

A number of new items of equipment from the range of products of PHILIPS ELECTRICAL, LTD. are to be seen on Stand 224. They include magnetic filters, resistance welders, arc welders and electronic instruments. The additions to the resistance welding range include a 50 kVA. single and repeat spot welder, a 15 kVA. pedal-operated spot welder, and a 20 kVA. pedal-operated spot welder, whilst the two latest arc welding transformers are the ES.3566, with a capacity of 12 s.w.g. to $\frac{5}{16}$ in. electrodes, and 60–350 amps, and the ES.1475 oil-cooled transformer to B.S.S.638, for which the corresponding figures are 16 s.w.g. to $\frac{1}{4}$ in., and 25–300 amps. The electronic roughness tester has been developed for the assessment of the surface roughness of a machined part in the workshop, using a roughness standard for comparison.

On Stand 178, which houses the exhibits of the DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, the Mechanical Engineering Research Organisation's display deals with the mechanics of cutting and the theory of machinability of metals, and shows the effects of temperature, work hardening, tool wear and cutting fluids on the machining process. On the same stand, the Metrology Division of the N.P.L. are showing historical and modern measuring instruments.

Of special interest on Stand 88, where LINCOLN ELECTRIC CO., LTD. are showing a wide range of equipment for electric arc welding, are the demonstrations of the latest submerged arc welding equipment—the Manual Lincolnweld and the Full Automatic Lincolnweld. The former combines the flexibility and manœuvrability of manual welding with the smooth spatter-free welds produced by hidden arc welding. The exhibits include welding generators and transformers and a special display of Lincoln Shield-Arc electrodes and accessories.

Before a steel bar can be drawn through dies on the drawbench, it is necessary to reduce the size of the end of the bar so that it may be threaded through the die to be gripped by the dogs. A new machine for this purpose is being shown by MAIDEN & CO., LTD. on Stand 113.

Even in the best-run engineering shops, the occasion arises when a tap breaks leaving the threaded part in the hole, an event which gives rise to the difficult problem of removal. On Stand 62, GASTON E. MARBAIX, LTD. are showing one of the answers. It is the Marbaix M-51 Disintegrator. Apart from the removal of broken taps, drills, reamers, etc. from machined parts without distortion of the component, it will cut holes in any type of hardened steel, drill holes at any angle, cut or enlarge keyway slots in cutters, dies, etc.

A range of oils for lubrication and heat treatment operations are to be seen on Stand 234 (EDGAR VAUGHAN & CO., LTD.). Included in the specialities of this Company are cutting oils, quenching oils and oils for lubrication in deep drawing operations.

A number of interesting magnetic devices are to be seen on Stand 212 [JAMES NEILL & CO. (SHEFFIELD), LTD.]. The range of magnetic chucks has been increased by the introduction of the Eclipse AX.1812 chuck, 18 in. × 12 in. which is designed on the unit principle for building up bigger chucks. Other magnetic aids to production are Eclipse magnetic floaters designed to speed up the

Continued on page 146

New Elektron Magnesium-Zirconium-Zinc-Thorium Casting Alloy

THE development in 1946, by Magnesium Elektron, Ltd., of a commercial process for alloying zirconium with magnesium, without introducing chloride contamination, marked a great step forward in the technology of magnesium alloys. The use of the powerful grain refining properties of zirconium upon magnesium made possible the preparation of a series of alloys containing zirconium, zinc and the rare earth metals which possessed physical and mechanical properties far beyond anything hitherto obtainable from magnesium alloys, and which represented the most important contribution to the progress of the magnesium industry since the establishment of the standard Elektron range of alloys some 25 years previously.

The development of jet engines created a demand for light alloy sand castings capable of withstanding elevated temperatures without excessive distortion. To meet this demand the alloys now so well known under their Trade Marks MCZ (developed in collaboration with J. Stone & Co., Ltd.) and ZRE1 were introduced. These alloys contain about 3% cerium mischmetal, and possess outstanding creep resistance at temperatures up to 250° C., combined with excellent mechanical properties, freedom from microporosity and exceptionally good founding characteristics.

As jet engine designers and constructors continued to increase the power of the latest jet engines, it became clear that the higher temperatures to which many of the magnesium components would be subjected would exceed the safe working range of the present alloys MCZ and ZRE1. M.E.L. therefore carried out intensive research with the object of developing new alloys giving still higher resistance to creep and still better fatigue strength at these higher temperatures.

Professor Sauerwald in the year 1939 was apparently the first to discover that the element thorium can also exert a marked beneficial effect in improving the creep resistance of magnesium-zirconium-mischmetal alloys at elevated temperatures. M.E.L.'s work as now proved that magnesium-zirconium-thorium alloys possess a much better creep resistance at elevated temperatures than those in the magnesium-zirconium-mischmetal-thorium system. Further research in tests extending over 1,000 hours has proved conclusively that addition of zinc to the magnesium-zirconium-thorium system, to provide a certain zinc-thorium ratio, has a most profound beneficial influence both on the creep resistance and fatigue resistance properties at elevated temperatures. M.E.L. has selected a magnesium-zirconium-zinc-thorium alloy, to be named Elektron ZT1, as being that alloy which possesses the best combination of properties at temperatures in excess of 300° C., and it is this alloy which M.E.L. now confidently recommends for use in castings which are expected to withstand temperatures in the range 250°–350° C.

TABLE I.—TENSILE TEST RESULTS.

Condition	Temperature of Test	0·1% Proof Stress tons/sq. in.	Ultimate Tensile Stress tons/sq. in.	Elongation % on 2 in.
Stabilised 16 hours at 315° C.	Room Temperature	5–6	12–14	5–10
As Cast	275° C.	—	5·4	50
As Cast	300° C.	—	4·8	45
As Cast	325° C.	—	4·5	40
As Cast	350° C.	—	4·3	35

The curves in Fig. 1 show that at 315° C. ZT1 has a much lower creep rate at a stress of 1·5 ton/sq. in. than has ZRE1 at half the stress, whilst it will be seen from Fig. 2 that, at the same stress of 0·5 ton/sq. in., the creep rate of ZT1 at 350° C. is of the same order as that of ZRE1 at 250° C.

Engine designers will continue to use ZRE1 up to 250° C. and now they have available alloy ZT1 for the hotter castings which have to withstand temperatures between 250° and 350° C.

Properties of ZT1 Alloy

Composition.—Nominally the alloy contains 3% thorium, 2·5% zinc and 0·7% zirconium.

Tensile Data.—Typical results of tensile tests made on D.T.D. test bars are given in Table I.

Creep Properties.—The creep properties set out in Table II are shown graphically in Figs. 1 and 2.

Fatigue Properties.—Single-point loading alternating bending fatigue tests carried out at elevated tempera-

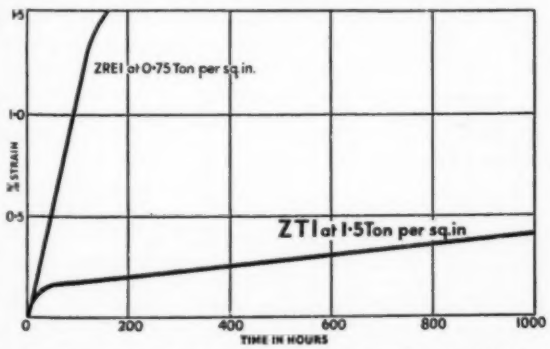


Fig. 1.—Creep curves for ZT1 and ZRE1 at 315° C.

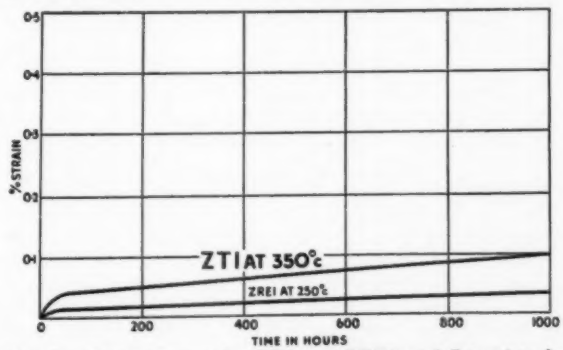


Fig. 2.—Creep curves for ZT1 and ZRE1 at 0.5 ton/sq. in

TABLE II.—CREEP TEST RESULTS.

Temperature of Test—° C.	Stress tons/sq. in.	Creep Rate in in./hr.	Total Plastic Strain—%
315	0·75	$1·2 \times 10^{-6}$ (200/1,000 hr.)	0·10 (200 hr.)
	1·0	$1·5 \times 10^{-6}$ (200/1,000 hr.)	0·15 (200 hr.)
	1·5	$1·5 \times 10^{-6}$ (500/1,000 hr.)	0·28 (500 hr.)
350	0·5	$2·0 \times 10^{-7}$ (200/1,000 hr.)	0·04 (200 hr.)
	0·75	$> 3·5 \times 10^{-7}$ (500/700 hr.)	0·90 (700 hr.)
	1·0	$4·3 \times 10^{-5}$ (800/1,000 hr.)	1·5 (800 hr.)

TABLE III.—FATIGUE TEST RESULTS.

Temperature of Test—° C.	Fatigue Limit on Notched Test Piece for Specified Reversals—tons/sq. in.			Fatigue Limit on Unnotched Test Pieces for Specified Reversals—tons/sq. in.		
	10^7	5×10^7	10^8	10^7	5×10^7	10^8
20		±4·5			±4·5	
200				±3·2		±3·2
250				±2·7		±2·7
315				±2·1		±1·5
350				±1·55		±1·05

tures on this alloy gave the results shown in Table III.

Corrosion Resistance.—Test results show that alloy ZT1 has the same order of corrosion resistance as have the existing high temperature magnesium alloys containing zirconium and mischmetal.

Castability.—The alloy is completely free from microporosity and can be handled in the foundry in the same manner as Elektron alloy ZRE1, which is one of the most castable light alloys.

Heat Treatment.—ZT1 requires no high-temperature solution heat treatment for the development of the maximum creep resistance and mechanical properties. A simple stabilising anneal at the maximum service temperature of the casting is the only heat treatment required.

Machine Tool Exhibition

Continued from page 144

handling of sheets, punchings and pressings, and an entirely new device, which will hold firmly ferrous sheet, tube or conduit during welding, marking out and certain machining operations, and can be turned on and off. In addition to the magnetic exhibits, the display includes a wide range of engineers' tools.

Among the hard metal tools, tipped tools and drawing dies shown by PROTOLITE, LTD. on Stand 217, are two recent developments, hard metal burrs and solid hard metal drills. Also to be seen on this stand are Murex sintered permanent magnets in Alnico, Alcomax and Hycomax, together with a display of the products of the Murex Powder Metallurgy Division covering the rarer metals: tungsten, molybdenum, tantalum and zirconium in the form of wire, rod, sheet and fabricated parts.

SAMUEL OSBORN & CO., LTD. are celebrating the centenary of their foundation this year, and the opportunity is being taken of showing on Stand 203 something of the history of the company, a comparison of production methods, and examples of present-day products. One side of the stand consists of three working models showing how the melting, forging and rolling of steel was carried out in 1852, whilst on the other side are shown the present-day methods. Interesting Mushet relics are on show, whilst to-day's products are represented by a display of tools, tool steels and stainless and heat-resisting steels.

A prominent feature on Stand 191 (THE RENOLD & COVENTRY CHAIN CO., LTD.) are the six roller chain drives representing typical applications used on various types of machine tools; these drives show to advantage the adaptability of chain drives in transmitting power to a number of shafts. Included in the comprehensive display are examples of conveyor chain suitable for swarf conveyors and similar applications.

BROOK MOTORS, LTD., on Stand 261, are featuring their new TC type fan-cooled motors which give practically identical performance with that of the totally enclosed type using only the same amount of active material as the open ventilated machine, the result being a considerable reduction in cost. Other exhibits include motors and control gear designed for cavity mounting on machine tools.

On Stand 251, C. A. NORGREN, LTD. are exhibiting the full range of Norgren air-line equipment, which includes air filters, lubricators and pressure regulators. The lubricators will feature in exhibits which demonstrate oil-fog and the new and revolutionary micro-fog.

The display on the Stand of M.T.E. CONTROL GEAR (255), comprises examples of specially designed electrical control panels and standard starters for all types of machine tools.

Products of the various members of the LANCASHIRE DYNAMO GROUP are to be seen on Stand 254, where the BRITISH ELECTRONIC PRODUCTS, LTD. display of the latest developments in the industrial electronic equipment field includes motor speed control units, protective and supervisory equipment and resistance welding machine control units. On the same stand, CRYPTON EQUIPMENT, LTD. are showing metal rectifiers capable of feeding motors and charging vehicle batteries, whilst industrial switchboards and the L.D.C. constant level oiler for ball and roller bearings are featured by LANCASHIRE DYNAMO SWITCHGEAR, LTD. and LANCASHIRE DYNAMO & CRYPTO, LTD., respectively.

On Stand 260, GUYSON INDUSTRIAL EQUIPMENT, LTD. have on show their complete range of light industrial shot-blast cabinets. Demonstrations are given daily to show the way in which hard surface deposits on light metals can be speedily removed at low operating costs.

Mechanical power transmission equipment, including belt drives, Platt clutches, anti-vibration mountings, etc., are displayed by J. H. FENNER & CO., LTD. on Stand 263, and on Stand 252, VEEDER-ROOT, LTD. are showing their range of mechanically and electrically operated counting mechanisms.

The display on Stand 151 (HALL & PICKLES, LTD.) will comprise small tools made from Double-Super-Hydra and Super-Hydra high-speed steels and Hydraloy hard metal. Small tools will also be shown on a number of other stands, including: 169 (WILLIAM JESSOP & SONS, LTD.), 193 (RICHARD LLOYD, LTD.), 226 (THE SHEFFIELD TWIST DRILL & STEEL CO., LTD.), and 91 and 92 (BRAYSHAW FURNACES & TOOLS, LTD.).

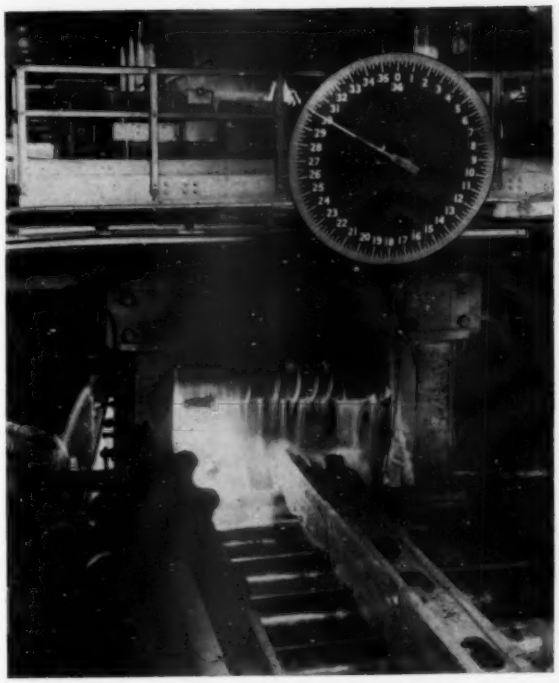
A Modern Rolling Mill Drive

ALTHOUGH there are still in operation in this country a number of rolling mills driven by steam engines, their number is gradually diminishing as modernisation schemes for first one and then another incorporate the replacement of the steam engine drive by an electrical one. A notable example of such a change is to be found in the 42½-in. cogging mill at the Redbourn Works of Richard Thomas & Baldwins, Ltd., at Scunthorpe, where The General Electric Co., Ltd., has supplied the whole of the electrical equipment for the main and auxiliary drives, the G.E.C. cascade exciter system being employed to ensure rapid and precise control of the mill.

The rolling mill at Redbourn works comprises a battery of gas-fired soaking pits, the 42½-in. cogging mill, a bloom shear and a 36-in. single stand finishing mill; the average weekly output of the mill in billets and slabs is of the order of 6,000 to 6,500 tons finished weight.

There are four long-type regenerative soaking pits fired with a mixture of blast furnace and coke oven gas, and a one-way fired pit burning coke oven gas. Each of these pits is capable of holding 20 of the standard 3-ton ingots or 16 of the 5-ton slab ingots. The installation is completed by six Stein and Atkinson recuperative cubicles, mixed-gas fired and each capable of holding six 3-ton ingots or three 5-ton ingots.

The cogging stand has rolls with 42½-in. centres and 9 ft. barrel, and prior to the electrification these rolls were driven by a Galloway three-cylinder reversing steam engine. The products of the cogging mill are slabs varying from 9 in. to 34 in. in width and 1¾ in. to 6 in. in thickness, and blooms of 5 in. square and upwards. The 20-in. square section 3-ton ingots are cogged into a 5½-in. square for the finishing mill in 19 passes, after which they pass to the Davy down-cut shears, and thence to the finishing mill with its rolls of 36-in. centres and 7-ft. barrel. The products of this mill, 2 in. to 5 in. square billets and slabs from 4 in. to 8 in. wide by 2 in. thick, pass through an electrically-driven shear prior to transfer to one of the four cooling beds. The large slabs, rolled in the cogging mill from the 37½ in. × 19 in. 5-ton slab ingots, by-pass the finishing mill.



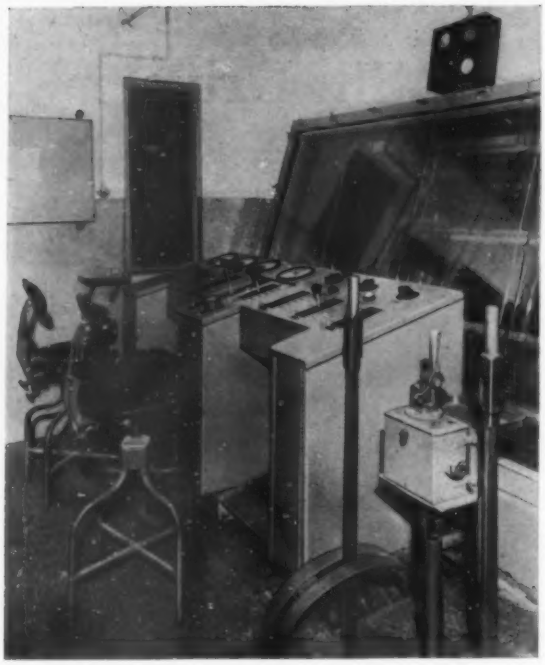
The 42½ in. cogging mill at the Redbourn Works, showing an ingot entering the rolls.

Electrical Equipment

The cogging mill is driven by a 5,000 h.p., r.m.s., D.C. motor housed in a motor room adjacent to the mill, which also contains the Ward-Leonard Ilgner set which supplies power to the mill motor, the main switchboard and control desk, and the liquid starter and slip regulator for the driving motor of the Ward-Leonard set. To prevent the ingress of dust from the mill, an air pressure of ¼ in. water gauge is maintained inside the motor room by means of two electrically-driven fans mounted in the roof; the fans also supply cooling air to the machines in the motor room. The basement of the motor room houses the main and cascade exciter sets for the mill drive, an auxiliary motor generator set and a cascade exciter set for the screwdowns and breast rolls, and three reversible high-speed circuit-breakers which protect the main generators. For the screwdown and breast roll auxiliary drives standard steelworks motors are used and all drives are controlled from a desk in a pulpit overlooking the mill.

The main mill motor is a compensated, shunt wound, reversing machine operating over a speed range of 0–50 r.p.m. by Ward-Leonard control, and from 50 to 100 r.p.m. by shunt control, and is rated at 5,000 h.p., r.m.s. at ±700 volts, with a working peak of 12,500 h.p. at 50 r.p.m. and a maximum cut-out peak of 15,000 h.p. at the same speed. It is equipped with two pedestal journal bearings which are flow-lubricated from motor-driven oil pumps and the oil circuit incorporates a flow indicator with alarm contacts.

The D.C. supply for this motor is provided by an Ilgner motor generator set consisting of three D.C. generators directly coupled to a 3,000 h.p. slip-ring induction motor. The flywheel is 9 ft. 6 in. in diameter and 32¾ tons in weight and is designed to give a total stored energy of 150,000 h.p. seconds. The induction motor, which operates from an 11 kV. supply and drives the set at approximately 735 r.p.m., has a synchronous speed of 750 r.p.m. and a maximum operating peak of 6,000 h.p. for 15 seconds. Each of the three generators has an output of 1,333 kW., r.m.s., at 700 volts and a maximum operating peak of 3,332 kW. for 15 seconds. The three machines are normally connected in parallel but change-over links are provided to enable the mill to be run at reduced output with any selected pair of



The control pulpit of the cogging mill.

generators. The machines are fitted with forced-lubricated bearings, which, with the exception of the two outer bearings, are water-cooled. The flywheel runs in swivelled pedestal bearings, 13 in. in diameter and 27 in. long, which are also forced-lubricated. All bearings are fitted with pressure gauges and dial-type thermometers with alarm contacts. The lubrication equipment for normal operation comprises two geared oil pumps which are belt-driven from the flywheel shaft, but for starting up and standby purposes two electrically-driven pumps are provided.

The Screwdown motors are of the standard steelworks type and are rated at 100/200 h.p., 230/460 volts, 475/950 r.p.m. They are mounted on a platform above the cogging mill and are forced-ventilated from the main ventilating fans in the motor room. The breast roll motors are also of the steelworks type and are rated at 25 h.p., 230 volts, 1,300 r.p.m.

The main switchboard for the control of the D.C. and auxiliary A.C. supplies is of the open flatback type and is designed for remote operation from control desks in the motor room and the mill pulpit. Each starter is controlled by means of start and stop push buttons with red and green indicator lamps, and sequence interlocking is provided. The desk is fitted with an annunciator panel which indicates any failure in the auxiliary A.C. circuits, and audible warning of the fault is also given by means of a Klaxon horn mounted on the main switchboard. The mill will continue to run for a period of three minutes from the occurrence of such a fault, to enable a newly-started ingot to be finished; at the end of the three minutes, the whole mill is automatically shut down.

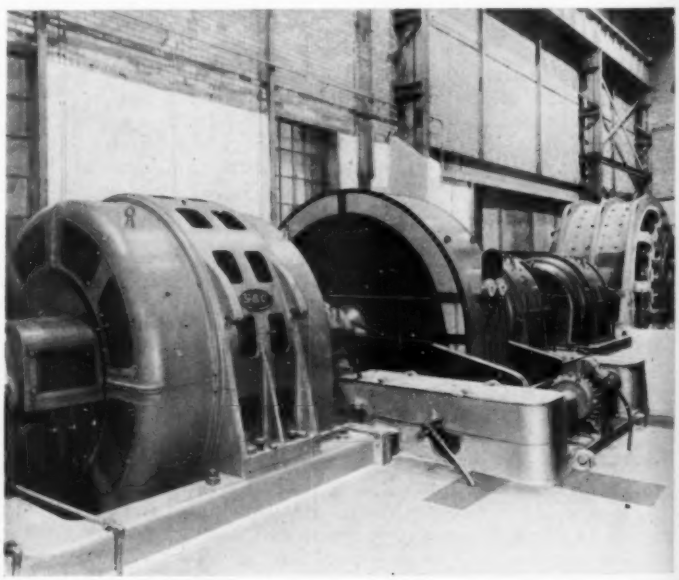
The main drive, screwdowns and breast rolls are controlled from the mill pulpit desk by means of cam type reversing controllers. Similar controls are provided for the ingoing and outgoing racks, and the desk is fitted with a speed indicator for the main drive and a position indicator for the screwdowns. A "stop" push button placed in the centre of the desk, in a position convenient to both operators, enables the entire mill to be shut down in the event of an emergency.

The liquid starter and slip regulator for the 3,000 h.p. induction motor of the main motor generator set has moving and fixed electrodes in the form of phosphor bronze grids operating in rubber-lined steel pots which are entirely immersed in the solution. In the full-on position, the electrodes are prevented from making contact with each other, the amount of resistance left in the circuit being such that the slip is limited to 10% at the full-load torque of the motor. The electrolyte is circulated by a 1½ h.p. pump and the liquid starter is operated by a D.C. motor fitted with limit switches and interlocking contacts.

The Control System

The cascade exciter control system which has been adopted for the main mill and screwdown drives is a method of energising the field of a large generator in such a manner that the excitation can be varied and, if necessary, reversed, in the minimum of time and by the expenditure of a very small amount of electrical energy in the initiating circuit. The cascade exciter system is used in conjunction with Ward-Leonard control and is applied to the fields of the generators which supply the main driving motors.

To change or reverse a large field quickly, an exciter giving a maximum voltage of up to six times the normal



3,000 h.p. Ward-Leonard set in the motor room, with the cogging mill motor in the background.

field voltage is required, and such an exciter requires appreciable power in its own field circuit. By using a pilot exciter to provide the excitation of the main exciter, the power required to initiate a change in the main generator field is reduced, and if the pilot exciter is also designed to give a far higher voltage than is normally required, a rapid response is obtained. To ensure this rapid response, both exciters must have completely laminated iron circuits, but apart from this feature and the provision of two additional field windings on the pilot exciter to prevent hunting, they are standard D.C. machines.

Hunting is prevented by connecting one of the additional windings on the pilot exciter across the output of the main exciter and the other in series with the armature of the main exciter. Under steady conditions, the windings neutralise each other and there is no resultant effect on the field. When the current in the main generator field is changing, the pilot fields are unbalanced by the inductance of the generator field, and an extra magnetising force is applied to the exciter field which has the effect of preventing the system from hunting.

For the control of the main mill motor, which has an armature weighing 58 tons, three exciters connected in cascade are employed, and with this system, the change from full speed forward to full speed reverse can be accomplished in 5½ seconds, the corresponding time for base speed forward to base speed reverse being two seconds.

Acknowledgment

Acknowledgment is due to Richard Thomas & Baldwins, Ltd., and to The General Electric Co., Ltd., for permission to publish the foregoing information and illustrations.

Automatic Control of Soaking Pits

AN interesting application of instrumentation in the steel industry is provided by six soaking-pit furnaces at the works of The Llanelly Steel Co. (1907), Ltd., Llanelly, Camarthenshire, which are automatically controlled by means of an air-operated regulating system. Each pit has a separate control panel, similar to that shown in the illustration, incorporating instruments for the measurement and control of temperature and of the flow of fuel, air and steam. The panels were supplied by George Kent, Ltd., to the orders of The Salem Engineering Co., Ltd., who designed and provided the soaking pits.

A thermocouple in the soaking pit works with the electronic potentiometer *A* to indicate and record the pit temperature, and a controller in the instrument maintains the temperature at a pre-set value by operating a diaphragm valve controlling the fuel-oil supply. Measurement of the oil flow is by a PL-type orifice working in conjunction with the mercurial meter *B*, which is fitted with a pneumatic transmitter, the output pressure from which is proportional to the oil flow and is used to position the control pointer in the ring balance meter *C*. Meter *C* measures the combustion-air flow to the pit, and is fitted with a pneumatic controller which operates a power cylinder activating a butterfly valve in the combustion-air supply pipe. As the combustion-air requirements are set by the oil flow meter *B*, a definite air-to-fuel ratio is maintained over the meter range by the control system. *D* is a sensitive furnace pressure controller, utilising a power cylinder to operate the flue damper. Change-over from automatic to manual control, if required, is effected by the use of the three sub-panels *E*, *F* and *G*. Another mercurial meter *H* is employed for indicating and recording the atomising steam flow, and a multi-point recorder *I* is used to obtain a graphic record of recuperator temperatures. Pressures and temperatures of both atomising steam and fuel oil are indicated on the four gauges *J*.

We are indebted to The Llanelly Steel Co. (1907), Ltd., for permission to present this information and to reproduce the illustration.

New I.M.F. Branch

THE first technical meeting of the newly-formed Manchester Branch of the Institute of Metal Finishing (incorporating the Electrodepositors' Technical Society) was held on September 11th, at 7-30 p.m. in the Engineers' Club, Albert Square, Manchester, when the speaker was the President of the Institute, H. Silman, Esq., B.Sc., F.R.I.C., A.M.I.Chem.E.

International Conference

BRITISH DRIVER-HARRIS CO., LTD., of Manchester, inform us that the 4th International gathering of associates and distributors of the Driver-Harris organisation will be held at Alderley Edge, Cheshire, on October 8th, 9th and 10th, and will constitute a Technical Development Conference. A major part of the 3-day meeting will be occupied by discussions on a number of technical papers (previously circulated) dealing with the various aspects of the Driver-Harris alloys and new fields of application.

NEWS AND ANNOUNCEMENTS

Corrosion of Steel under Protective Finishes

A MEETING organised by The Iron and Steel Institute in conjunction with the British Iron and Steel Research Association, to discuss papers on the corrosion of steel under phosphate coatings and protective finishes, will be held at the offices of The Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, on Tuesday, 28th October, 1952, commencing at 2 p.m. Mr. H. T. Shirley, Chairman of the Corrosion Committee of B.I.S.R.A., will be in the Chair.

The following are the papers to be discussed; they have already been published in the *Journal of The Iron and Steel Institute* in the issues indicated:—

"Phosphate Coatings as a Basis for Painting Steel," by the PHOSPHATE COATINGS (DRAFTING) PANEL of the British Standards Institution. (January, 1952, pp. 10–15.) (To be presented by DR. J. C. HUDSON, Chairman of the Panel.)

"Corrosion by Retained Treatment Chemicals on Phosphated Steel Surfaces," by S. G. CLARKE and E. E. LONGHURST. (January, 1952, pp. 15–18.)

"Tentative Analytical Tests for Phosphate Coatings on Steel," by R. ST. J. PRESTON, R. H. SETTLE and J. B. L. WORTHINGTON. (January, 1952, pp. 19–20.)

The foregoing three papers will be discussed jointly.

"Second Report of the Methods of Testing (Corrosion) Sub-Committee." (July, 1952, pp. 255–272.) (To be presented by DR. J. C. HUDSON, Chairman of the Sub-Committee.)

A few reprints of the papers are available at 1s. each for the paper by Preston, Settle and Worthington, and 5s. each for the other three; requests, accompanied by a remittance, should be sent to the Secretary of The Iron and Steel Institute.

The Meeting will be open to all interested in the matters under discussion. There will be no charge for admission, but tickets will be required, and these can be obtained from the Secretary of The Iron and Steel Institute.

Society of Chemical Industry

Corrosion Group Meetings

A MEETING of the Corrosion Group of the Society of Chemical Industry will be held in the Chemical Society's Rooms, Burlington House, Piccadilly, London, W.1, on Wednesday, 8th October, 1952, at 6-30 p.m., when a Discussion will be held on "Filiform Corrosion and Related Phenomena." Opening contributions to the discussion will be made by Mr. R. J. Brown (Morris Motors), Mr. F. Hargreaves (British Railways), Mr. J. E. Kayser (Gillette Industries) and Dr. C. F. Sharman (Imperial Tobacco Company). This meeting should provide an excellent opportunity for a comprehensive examination of the practical and theoretical aspects of this subject. An indication of the general nature of the topics under discussion can be obtained from a study of the following references: C. F. Sharman, *Nature*, 20th May, 1944, p. 621; F. Hargreaves, *J. Iron and Steel Inst.*, May, 1952, p. 47; and J. F. Kayser, *Metal Treatment*, March, 1952, p. 111.

A Joint Meeting with the London Centre of the Institute of Metal Finishing will be held at the Northampton Polytechnic, St. John Street, London, E.C.1, on Monday, 20th October, 1952, at 6 p.m., when the following papers will be presented: (1) "Tin-Nickel Alloy and Nickel-Chromium Coatings: Some Comparative Corrosion Tests," by S. C. Britton and R. M. Angles; (2) "Tin-Nickel Alloy Coatings: Methods of Testing Thickness and Porosity," by S. C. Britton and D. G. Michael.

The Royal Photographic Society's Exhibition

THE Royal Photographic Society's 97th Annual Exhibition which opened on Thursday, 11th September, 1952, in the Society's House, 16, Princes Gate, S.W.7, will remain open to the public without charge until Sunday, 12th October, 1952, inclusive, from 10 a.m. to 8 p.m. each day (Saturdays, 10 a.m. to 5-30 p.m.; Sundays, 2-30 to 5-30 p.m.). The Exhibition will close at 6 p.m. on Tuesdays, so that the miniature colour transparencies can be projected, with commentary, at 7 p.m.

The Society's Annual Exhibition is recognised as the premier photographic exhibition, comprising as it does all types of photograph. Over 5,000 entries were received, of which 849 have been accepted. There are 10 sections of the Exhibition and the voluntary services of 38 selectors are required. The purpose of the Exhibition is to show work which provides a fair cross-section of contemporary photography, as shown by the material which is submitted for consideration.

The Society celebrates its Centenary next year and throughout its long history there have been only two occasions when its Annual Exhibition has not been held; one in 1862, when the Government held a Great Exhibition, in which photography figured, and the other in 1866, when the Council of that day seems to have been uncertain about the number of visitors likely to be attracted. Even during the two world wars the Exhibition was continued in London without a break.

After the London display the whole of the Exhibition will be transferred to Leeds, where it will be opened by H.R.H. The Princess Royal in the City Art Gallery, on Saturday, October 25th, and will remain open to the public until Sunday, November 23rd. Thence it will go to Bristol where Lord Methuen will open it in the Art Gallery on Saturday, December 6th, prior to a further showing there until Wednesday, December 31st.

Aluminium Roof Covering

THE Aluminium Development Association has just installed at the Building Centre, 26, Store Street, London, W.C.1, a display of full-scale models illustrating recommended practice for fully-supported roof covering in aluminium. The exhibit, executed by a practical plumber to the Association's designs, demonstrates the application of various grades of aluminium to this work, and the very high standard of workmanship and effective roofing that can be achieved with these materials.

The materials used are Aluminium (99·99%); S1A (99·8%); S1B (99·5%); S1C (99%); and NS3

(aluminium-manganese alloy) B.S. 1470, all in the "0" or soft condition. It will be seen from the exhibits that these materials respond equally with all the traditional methods employed with older types of roofing metals and craftsmanship. The application of aluminium to roofing has now been practice for over half a century and from the earliest development of this metal, its suitability for this purpose has been fully established.

Information on this and other subjects on the use of aluminium is available on application to the Aluminium Development Association, 33, Grosvenor Street, W.1.

Welding Engineers' and Supervisors' Instruction Course

In addition to courses for welding operators and for designers and draughtsmen, The Quasi-Arc Company Ltd. have courses lasting for three weeks for welding engineers, supervisors, inspectors and foremen. About half the time is allotted to technical and theoretical work and half to practical welding experience. The lectures and practical demonstrations include: (1) establishing welding procedures; (2) electrode design—characteristics of electrode coverings; (3) the uses and applications of the various types of electrodes; (4) weldability of ferrous and non-ferrous metals; (5) radiographic examination of welds, methods employed, typical faults and practical demonstrations; (6) control of distortion and residual stresses; (7) duties of welding inspectors and supervisors; (8) design for welding; and (9) economics of arc welding. The lectures are illustrated by lantern slides and films.

The next three-weeks' course will commence on 27th October, 1952. Application for enrolment should be sent to The Quasi-Arc Company Limited, Bilston, Staffordshire or Bridgewater House, Cleveland Row, St. James's, London, S.W.1. Local accommodation is arranged near the Bilston Works.

New Hungarian Natural Resources Discovered

Since 1945, experimental drillings in Hungary for water, coal, ores, mineral oil and natural gas have equalled a quarter of the drillings carried out during the previous 100 years. Reports in the Hungarian Press indicate that intensive prospecting has revealed deposits of lead and zinc, and that extraction is due to begin in 1953. Home needs of these metals are expected to be satisfied by the end of 1954. Prospecting has also revealed deposits of manganese ore, and reserves are believed to be sufficient for home requirements and for export. Iron ore, which is in great demand, has been found in considerable deposits. Additional research is being made with the aim of smelting bauxite ore rich in iron, in order to increase iron supply.

David Brown Australian Venture

Latest development in the David Brown policy of progressive expansion is the formation of a new company, David Brown (Australasia) Pty., Ltd. With headquarters at 82, Pitt Street, Sydney, Australia, the new company will be responsible for the importation and distribution throughout Australasia of the various products of David Brown Tractors (Engineering), Ltd., of Meltham, Yorkshire, namely, agricultural tractors and implements, industrial tractors, stationary engines and marine engines. Mr. P. J. Clifford, former Export Sales Manager at Meltham, who went out to Australia a year ago, has been appointed Manager of the new company. This is the third new David Brown company which has been established in Commonwealth countries since the war. The other companies are in South Africa and Canada.

A New Powder Metallurgy Bulletin

Metallwerk Plansee G.m.b.H., of Reutte Tyrol, Austria, who are well known as one of the leading European exponents of powder metallurgy, announce that they are publishing a technical periodical *Plansee Berichte Für Pulvermetallurgie*. This will contain technical reports on research and developments in the powder metallurgical field and details of new applications of powder metallurgy in industry, etc. It will be printed in German, and the first number is expected to be published in the next few weeks.

This periodical will be available through Metro-Cutanit, Ltd., 160, Piccadilly, London, W.1, the U.K. representatives of Metallwerk Plansee, to whom all persons or organisations wishing to subscribe are requested to apply.

Cheaper Aluminium for Packaging

Price reduction for thin gauge aluminium sheet and strip for boxmaking, canning and capping purposes are announced by The British Aluminium Co., Ltd., and Northern Aluminium Co., Ltd. Varying in amount up to 8%, these reductions make aluminium for these purposes more competitive with tinplate than at any period since the war. The substantial extension to their rolling mill capacity made by these companies has no doubt played its part in achieving these reductions. The British Aluminium announcement adds that its new rolling equipment also makes possible the inclusion of a stronger alloy for boxmaking at prices previously charged for pure aluminium and 1¼% manganese alloy.

Smithson Research Fellowship

A Joint Committee consisting of representatives of the Royal Society and the University of Cambridge have appointed Dr. R. J. Eden, M.A., Ph.D., of Cambridge University to be Smithson Research Fellow for four years in the first instance from October 1st, 1952. Dr. Eden will work on the Theory of Fundamental Particles at Cambridge University.

Opening of Newcastle Office

British Driver-Harris Co., Ltd., whose headquarters are at Manchester, announce that a new Branch Office was opened on September 15th, at 27, Grey Street, Newcastle-on-Tyne, 1. The new office will deal with enquiries and matters relating to all sizes and types of Drivex Electric Cable. As soon as possible a stock will be held in Newcastle for delivery in an area bounded roughly by a line drawn from Lancaster to the East Coast and

northwards to the Scottish border. The office will deal also with problems arising in the area concerning British Driver-Harris alloys, including electrical resistance materials (Nichrome, Advance, Thermocouple Alloys, etc.). The manager of the new office will be Mr. B. S. Lockett, who until now has held an executive position at Manchester.

BISRA Council Changes

Mr. H. H. Burton, C.B.E. has been appointed a Vice-President of the British Iron and Steel Research Association in place of Prof. Sir Alfred Egerton, F.R.S. who has resigned. The changes in Council membership include the appointments of Mr. R. S. Brown, M.B.E., Mr. H. Bull, Mr. W. F. Cartwright, Mr. M. A. Fiennes, Mr. C. E. Holmstrom, Capt. M. Morris, Mr. J. H. Patchett, Mr. G. L. Bailey, C.B.E., Dr. J. W. Jenkin and Prof. H. O'Neill, the retiring members being Capt. H. Leighton Davies, C.B.E., Mr. S. Thomson, Mr. A. M. Lee, Mr. E. T. Judge, Mr. A. Reith Gray, Mr. T. Jolley, Mr. C. H. T. Williams, Mr. H. H. Burton, Mr. A. Catton and Dr. A. T. Green.

Private Trading in Lead

In order to avoid misunderstanding about the disposal of Government lead stocks, the Ministry of Materials wishes it to be known that it is not its policy to release more than a relatively small tonnage for sale during the early months of the operation of the London Metal Exchange, which opens on October 1st. The Ministry is satisfied that this tonnage will be adequate to meet the requirements of consumers. The metal to be disposed of will be made available through the London Metal Exchange and through the usual trade channels. The Ministry reserves the right to suspend selling when it is satisfied that sufficient lead is available from private sources to satisfy demand.

Developments by Elcontrol, Ltd.

Elcontrol, Ltd., who set out, about three years ago, to specialise in industrial electronic control equipment, have outgrown their original factory and have just moved into larger premises at Wilbury Way, Hitchin. At the same time their range of standard items is being increased and now includes a photoelectric pyrometer for resistance welding and heat treatment control, an electronic weld timer for use with all types of resistance welding machines, and an electronic proximity switch having very wide applications. They also announce advances in the realm of automatic ignition and flame failure control of gas-fired installations and have issued revised literature on this subject.

Sales Headquarters remain at 10, Wyndham Place, London, W.1. (Ambassador 2671).

Agency Appointment

Radiovisor Parent, Ltd., manufacturers of photo-electric equipment, announce that they have appointed Messrs. J. Broughton & Son (Engineers), Ltd., of "Security" Works, 234, Pershore Road South, Kings Norton Factory Centre, Birmingham, 30, sole selling agents for their photo-electric press brake guard. It should be noted, however, that all other Radiovisor products are still handled by Radiovisor Parent, Ltd., from their Head Office at 1, Stanhope Street, London, N.W.1.

Personal News

Mr. T. E. Goldup, a Director of Mullard, Ltd., has been appointed Chairman of the Board of Governors of the Ministry of Supply School of Electronics, Malvern, in succession to Professor Willis Jackson, Professor of Electrical Engineering, City and Guilds College, London.

The Steel Company of Wales announce that Mr. Glyn M. Jones, Personnel Superintendent of the Steel Division, has relinquished his position for health reasons, but is continuing in the service of the Company in an advisory capacity. He has been succeeded by Mr. Campbell Adamson who joined the staff of Messrs. Baldwins, Ltd., in 1944. In 1947, he was appointed Assistant Labour Relations Officer to the West Wales Section of Richard Thomas & Baldwins and later became Labour Officer for the section. In 1950 he was promoted as Assistant to the General Manager of the West Wales Group.

The Ministry of Supply announces that Mr. Handel Davies has been appointed Chief Superintendent of the Aeroplane and Armament Experimental Establishment at Boscombe Down, in place of Mr. J. Hanson who has been transferred to a Headquarters post. Mr. Davis served for many years at the Royal Aircraft Establishment, Farnborough, where he was latterly in charge of the Aerodynamics Flight.

The Plessey Co., Ltd., announce that Mr. J. Foster Veevers has been appointed General Manager of the Swindon Works. Previous to joining the Plessey Company, Mr. Foster Veevers was with the General Electric Co., Ltd., as Manager of the Stockport works of Salford Electrical Instruments, Ltd.

The Research and Development Division of the British Steel Founders' Association announces that Mr. F. Marshall has joined its metallurgical staff.

Mr. D. N. Gifford, M.B.E., has been appointed a Director of EFCO Engineering Co., Ltd., of Burton-on-Trent.

Sir Andrew McCance, Deputy-Chairman and Joint Managing Director of Colvilles, Ltd., has been appointed a member of the East Kilbride Development Corporation.

Mr. L. Chapman, a Managing Director of William Jessop & Sons, Ltd., the Sheffield manufacturers of special steels, has been elected a Director of the parent company, Birmingham Small Arms Co., Ltd.

Professor F. C. Thompson, Professor of Metallurgy in the University of Manchester, has been nominated President of the Institute of Metals for 1953–54. He will take office at the Annual General Meeting in March, 1953; in succession to Dr. C. J. Smithells.

Mr. Herbert Leslie Wyneken, Secretary and Chief Accountant of Edgar Allen & Co., Ltd., Sheffield, has resigned. He has been with the company since 1945. Mr. Wyneken is succeeded by Mr. Francis Alan Ross.

Obituary

We regret to record the death of Mr. C. Cyril Hall, a Special Director of Firth-Vickers Stainless Steels, Ltd., of Sheffield, who died on August 6th, aged 56. He was a former Chairman and Past President of the Sheffield Branch of the Institute of Welding and a member of the Sheffield Metallurgical Association.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

Direct Reading Brinell Tester

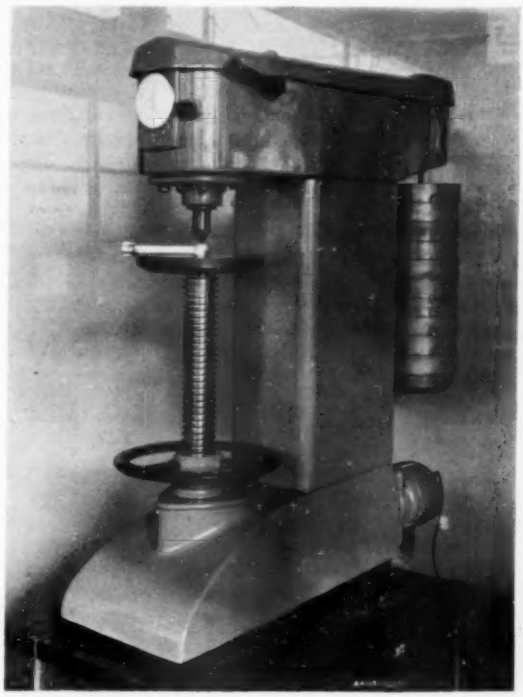
ENGINEERS, and production engineers in particular, have long sought for means to make hardness testing less of a laboratory and more of a production operation. On finished components or on materials with a high quality finish this can fairly claim to have been done by means of the Rockwell form of test and many thousands of machines of this type are now in use.

On raw materials such as steel and light alloy bars, forgings, drop stampings, castings, etc., the most satisfactory hardness test is the Brinell test in which a 10-mm. ball is forced into the material under a load of 3,000 kg., the diameter of the resultant depression being measured and translated from tables into a Brinell Hardness figure. In some cases a smaller ball and/or load is used in order to obtain the desired ratio of impression to ball diameter. The standard Rockwell test would not be suitable for these tests because the load is insufficient to penetrate the skin of the material, the size of the impression is too small and subject to localised variations in the material, and the surface of the material is subject to deformation and recovery under load.

On the other hand, although the Brinell test gives more reliable results under these circumstances, due to the comparatively large size of impression and the heavier loads employed, it also has its disadvantages, particularly in regard to high speed production and the use of unskilled or semi-skilled labour. For this test the surface must be prepared, usually by grinding a small facet for the impression in order to enable the diameter to be measured by microscope. The accuracy and ease with which the reading can be taken depends on how much care is taken in preparing this surface and it is this aspect which makes the Brinell test somewhat slow from a production angle.

Users of Brinell machines have for a long time asked for a direct reading machine and many attempts have been made to satisfy their demand. Some makers supply such direct reading attachments either built into the machine or fitted as an accessory. These devices generally consist of a dial gauge which measures the depth of impression and records the result either in Brinell numbers or on a comparator scale. Excellently made as some of these devices are, the difficulty with all such mechanisms is the setting of the base or zero from which the depth is to be measured. If the surface is machined or ground flat the results are reasonably good, but on the average ground surface, which is usually slightly concave, the results can be very variable. W. and T. Avery, Limited, have spent a number of years developing such devices and various experimental attachments have been made. None of these was placed on the market by them as there was some doubt as to the measure of reliability which users could expect from them.

As a result, however, of all this research and development, Avery have now evolved a direct reading machine, No. 6405, which they claim overcomes the failings of the previous attempts. As can be seen from the illustration, the machine is a development of their well-known power-operated Brinell machine, which applies the load by means of a lever and proportional weights acting on a floating frictionless penetrator, the hard work of applying and removing the load being performed by a motor-operated hydraulic pump and ram controlled by a finger tip lever. The machine remains a true Brinell machine, inasmuch as the impressions produced



are true Brinell impressions in accordance with B.S.S.240 Part 1 and can be read by microscope at any time. In addition, however, the machine is provided with a dial gauge which gives a depth reading which can be converted to a Brinell figure. The depth recorded is not the depth from the surface to the bottom of the impression but the difference between the depth of an initial impression under a load of 250 kg. and the final depth under the major load of up to 3,000 kg. The depth is read after the major load is removed so that frame and test piece distortions do not confuse the result. It will be seen that the system is similar to that used in the Rockwell test but it will be realised that, due to the greater loads and greater depth of penetration, most of the difficulties associated with this form of test disappear.

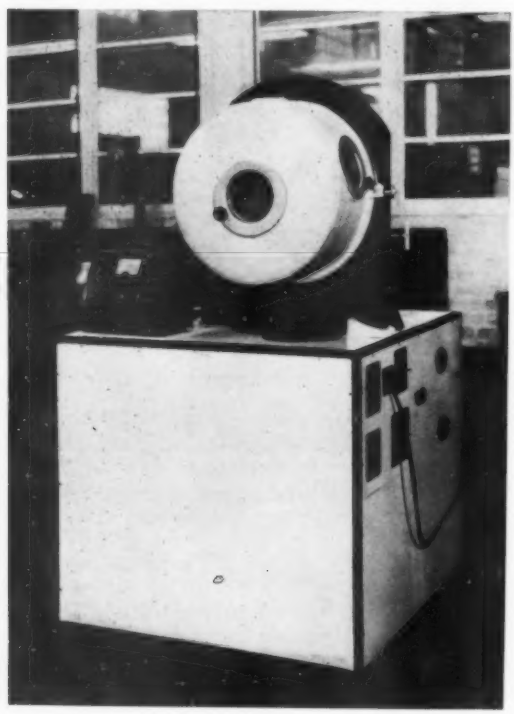
Tests with this machine show an astounding measure of reproduceability and the speed and ease of operation enable upwards of 300 tests an hour to be maintained without difficulty. For an average Brinell hardness of 250 where $P/D^2 = 30$, 5 divisions on the dial = 1

division of 0·1 mm. on the microscope. For harder materials the number of divisions on the dial become less and for softer material more. The permitted hardness tolerance can be rapidly established in terms of dial readings and thereafter it becomes a simple matter for the operator to check test pieces and reject those coming outside the permitted tolerance.

W. & T. Avery, Ltd., Soho Foundry, Birmingham, 40.

Laboratory Vacuum Furnace

As mentioned in our preview of the exhibits at the International Machine Tool exhibition at Olympia, Birlec, Ltd., are showing there a self-contained laboratory type vacuum furnace for heat treatment and melting applications; this furnace (as illustrated)—the Birlec-BAR type 2904 unit—achieves temperatures of up to 2,000° C., working in vacua down to 1 micron or less. Type 2904 has been designed for universal work—melting, degassing metals, heat treatment and sintering—and its application will mainly be found in fundamental and applied research work. Operation can be under vacuum or under controlled atmosphere conditions.



The equipment is contained in a cream-finished metal cabinet, which houses the vacuum pumping system and gauges, and on top of which is the furnace contained in a vacuum enclosure, designed for easy removal. The furnace itself is heated by a molybdenum or tungsten resistance element wound around the crucible, the whole being surrounded by a stainless steel sleeve. The largest size of crucible which can be accommodated in the type 2904 has a capacity of 19 cubic inches (6 in. high and 2 in. diam.), if half-filled, the crucible contains 3 or 4 lb. of steel, for which adequate melting capacity is available. The heating elements are readily replaceable and do not embody any refractories, thus giving improved vacuum conditions and eliminating the risk of contaminating critical melts.

The vacuum system consists of a new BAR type H4P oil diffusion pump, backed by a Kinney mechanical roughing pump, and suitable gauges are provided to measure the vacua obtained. The heat treatment or melting operations are controlled from outside the unit and when melting, for example, it is possible to add to the melt, stir it, or pour it under vacuum or controlled atmosphere conditions.

The overall dimensions of the complete 2904 unit are 3 ft. × 3 ft. × 5 ft. high, and its weight unpacked is 11 cwt. It operates from a normal commercial 415 volt, 3-phase, 50 cycle supply and requires 4 gall. per min. water flow at an inlet pressure of 15 lb./sq. in.

This unit is a joint product of Messrs. Birlec, Ltd., and British American Research, Ltd.

Birlec, Ltd., Tyburn Road, Erdington, Birmingham, 24.
British American Research, Ltd., Wishaw, Lanarkshire.

Vitrified Buff Tiles

In supplying their vitrified blue acid and alkali-resisting bricks and tiles, J. H. Sankey and Son Ltd. have discovered that there is a need for a tile having the same properties, but of a light colour. The result has been the production of a vitrified buff tile which possesses an unusual combination of properties. In addition to being highly vitrified and, therefore, extremely hard and long-wearing, it permanently withstands water, acids and alkalies. Its surface is non-slippery and its pleasant buff colour is light-reflecting. Such a tile is specially suitable as a flooring surface, particularly in chemical, food and other factories, and in laboratories, etc. It can also be used for lining acid or other storage tanks. There are two sizes available, each $9\frac{13}{16}$ in. × $4\frac{5}{8}$ in. but with thicknesses of $\frac{7}{8}$ in. and $1\frac{1}{2}$ in. respectively; the former is the more popular. For setting these tiles—especially in the construction of acid-resisting floors and tanks—Sankey's Super Acid-resisting Cement is recommended.

J. H. Sankey and Son, Ltd., Ilford, Essex.

Direct Reading Indicators

The 1950–51 report of the Medical Research Council featured the development of a new machine tool setting device by its Applied Psychology Research Unit. English Numbering Machines Ltd. announce that they have been privileged to co-operate in the development of these universal direct reading indicators, and that the commercial application thereof is in their hands, together with the exclusive rights to the instrument for which patents are pending in the following countries; Great Britain, Belgium, Canada, France, Germany, Italy, Sweden, Switzerland and the U.S.A. The Company will shortly be producing a range of models suitable for a variety of machines. The new instruments will make it possible to set machines to accurate limits without hesitation or mental arithmetic, and to attain substantial savings in setting times with almost complete elimination of human errors.

English Numbering Machines, Ltd., Queensway, Enfield, Middlesex.

CURRENT LITERATURE

Book Reviews

EINFÜHRUNG IN DIE FESTKÖRPERCHEMIE

Introduction To The Chemistry Of Solid Bodies

By Dr. J. Arvid Hedvall, 292 pages + viii; 82 illustrations in text. Published by Friedrich Vieweg & Sons, Brunswick, Germany. Price in England, 31s. 10d.

To the physicist, the chemist and the metallurgist, the work, now becoming practically the life-work, of Professor Arvid Hedvall of Gothenburg is of the greatest importance. As early as 1912, in one of his early scientific papers, he showed that reactions and double decompositions between solid bodies were not only a general property of matter, but could take place at remarkably low temperatures. In the sketch of the historical development of solid state chemistry, in this book, he points out that the subject is a younger branch of natural science, but that Faraday in 1820 had already published observations on diffusion in metals, well over 70 years before Roberts-Austen described the diffusion of gold in lead. Earlier than this, W. Spring had observed what he took to be solid reactions between barium sulphate and soda, but had not been able to obtain complete proof that his surmises were correct. G. Masing described the formation of an alloy of magnesium and antimony in which reaction had taken place in the solid state, and there was also the work of Tammann and his colleagues.

In 1938, Professor Hedvall's first book, "Reaktionsfahigkeit fester Stoffe," was published, and provided the first over-all account of the basis and the results of the study of reactability of solid matter. In it, the build-up or synthesis of solid matter and the energy relationships of crystal lattices was described, and the genesis and development of investigations into the chemistry of solid matter traced. The outbreak of war and the anxious times preceding it precluded any wide dissemination of the contents of the book, and the reproduction in 1943 of a photo lithoprint copy in America, although welcome, could only be a partial addition to the original publications.

Now we have this new book, "Einführung in die Festkörperchemie," which replaces and supplements the earlier book. This particular work should be translated into English, as it is unique and of instant value to all scientific workers engaged in manipulating solid matter and utilising it in any way which allows or requires it to react with other matter. It opens with a short but valuable account of the historical development of the chemistry of solid state material. The main body of the book then comprises five major divisions. Chapter (1) deals with the building up of solid bodies, (2) with the kinetics of the solid state, (3) with reaction in the solid state, and (4) with some selected examples of the practical significance and application of solid body chemistry, and here is presented a broad view of the tremendous extent of the field and of its importance in science and technology. From powder metallurgy and powder ceramics, through geochemical and petrological syntheses, the genesis of minerals, the crystal modifications in pigments and their significance, to problems in the manufacture of ceramics ranging from porcelain to refractories—to mention these is but to touch the fringe of the subjects. Finally, the fifth and last section comprises a most valuable "Atlas of Powder Reactions." Here the elements are arranged in their grouping in the periodic system and their compounds as is usually the case in textbooks, *i.e.*, oxides-carbonates-chlorides, etc. The components of each reaction are given and the product, together with the temperature at which reaction is just perceptible and traceable by a stated analytical procedure, and the temperature at which reaction appears to be complete. Other data and literature references are given and there is a literature index—also name and subject index. This is a work of which there most certainly should be an English translation. Professor Hedvall deserves the thanks of the whole scientific community for giving us this most excellent résumé of a field in which he has himself laboured magnificently.

H. W. Greenwood.

MATERIALS HANDLING IN INDUSTRY

142 pp., 109 illustrations. Published by The British Electrical Development Association, 2, Savoy Hill, London, W.C.2. Price 8s. 6d.

The text of this book, which appears on the dust cover is, "Every time a material is handled, something is added to its cost and nothing to its value." The book has been written with the object of showing how better materials handling can increase productivity and at the same time improve working conditions. It illustrates how better materials handling can be obtained by the judicious use of mechanical equipment—that is to say, when replanning or process integration will not obviate the handling of material altogether. Many kinds of mechanical handling equipment are in use to-day, each with its own attributes, but in most cases there is only one type which offers the best solution to any particular handling problem.

One of the objects of this book is to make the selection of the right one easier, by presenting in easy reference form the wide range of mechanical handling devices in general use, together with details of their construction, characteristics and duties. It should perhaps be added that this book deals with all types of equipment used in materials handling, and is not confined to electrically-driven or controlled appliances.

Trade Publications

We have received a beautifully illustrated brochure dealing with the Lamberton-built forging plant of Eumuco (England), Ltd., of 12, Great Portland Street, London, W.1. The range of plant covered includes horizontal forging machines for stock from 2 in. to 9 in. diameter; high speed vertical forging presses, from 500 to 8,000 tons capacity; high speed die forging hammers, from 10 cwt. to 25 tons falling weight; counter blow hammers; pneumatic hammers, from 5 cwt. to 60 cwt. falling weight; forging rolls; coining and sizing presses from 250 tons upwards, and a range of hydraulic and electro-hydraulic presses for extrusion, plate bending and ingot forging.

A NEW edition of the Lincoln Weldirectory is now available to anyone in the engineering or welding fields on application to the Lincoln Electric Co., Ltd., Welwyn Garden City, Herts. It contains details of a range of Lincoln products, from chipping hammers to diesel engine driven welders, but the greater part of the booklet is concerned with electrodes. The characteristics of the rods are set out together with the properties of the deposits, and recommended welding procedures given. In addition there are notes on weldability and an introduction to arc weld surfacing.

AT the beginning of last month, T.I. Aluminium, Ltd., introduced a new coding system for their alloys so that the reference numbers might be clearly related to the chemical composition of the alloys. The basis of the new system is a T.I. prefix to show T.I. Aluminium origin, a numeral indicating the alloy group according to the main chemical constituents and two further numerals indicating the alloy number.

AN eight-page publication, recently issued by the Equipment Division of Mullard, Ltd., describes the principles and methods of use of Mullard Ultrasonic Soldering Equipment. This equipment, which consists of an Ultrasonic Soldering Iron and an Ultrasonic Tinning Bath, makes possible the effective tinning of aluminium and other light metals without the use of flux. The applications suggested for this equipment include the tinning of electronic chassis assemblies, the soldering of connections to aluminium foil condensers, and the joining of aluminium lugs to stranded aluminium cables. The Ultrasonic Soldering Iron described in this new publication can also be successfully used for filling blow holes and other faults in light alloy castings.

THE latest catalogue issued by Wild-Barfield Electric Furnaces, Ltd., deals with the well-known horizontal "hairpin" furnaces. The features are described in considerable detail, reference being made to the Paragen system of atmosphere control. Applications for which this type of furnace is suitable include hardening, carburising, normalising and annealing, nitriding and vitreous enamelling.

IN the D.-A. Cyclonic Scrubber featured in a leaflet recently issued by The Power-Gas Corporation, Ltd., Stockton-on-Tees, the dirty gas enters tangentially at the bottom and pursues a spiral path upwards. Spray is introduced from an axially located manifold and in its journey towards the walls it collects the dust particles. This scrubber assures virtually complete removal of micron-size dust, whilst for sub-micron dust and mist the D.-A. Venturi Scrubber is described. In this model, dirty gas, at high velocity, impinges upon and atomises a curtain of liquid introduced through jets in the Venturi throat.

WE have received from W. Edwards & Co. (London), Ltd., Worsley Bridge Road, Lower Sydenham, London, S.E.26, a selection of new leaflets describing their vacuum equipment. E112/1 deals with three types of vacuum pumping units—mobile units, combined rotary and diffusion pump units, and cabinet mounted pumping systems, whilst A106/3 covers vacuum pipeline units supplying a laboratory vacuum service of 12 or 24 points. The P2 piston compressor and vacuum pump capable of supplying a pressure of 28 lb./sq. in. or a vacuum of 28 in. of mercury is detailed in A111/1, and the Circseal range of precision ground glass joints and Speedivac educational equipment in C103/1 and A116/1, respectively.

THE Besco range of sheet metal workers' hand tools and machines is the subject of a new catalogue by F. J. Edwards, Ltd., 359–361, Euston Road, London, N.W.1. The crafts covered by the items detailed therein are those of the sheet metal worker, the panel beater and the coppersmith, and in addition to hand tools, machines for hand operation are also featured.

TWO new data sheets have recently been issued by Elcontrol, Ltd., 10, Wyndham Place, London, W.1. No. 6 deals with the Elcontrol WT 2 weld timer, which is an industrial type short range electronic timer suitable for use with a wide range of resistance welding machines, and gives single stage non-synchronous timing with non-repeat control. A flame conductivity safety system for gas burners forms the subject of Data Sheet No. 7. This comprises an electronic control unit, embodying an amplifier and relay, electrically connected to a heat-resisting steel probe which makes contact with the conductive gas flame. Should the flame fail, the circuit is broken and the fuel valve is closed. Special features ensure failure to safety, but allowance is made for flame flicker by the provision of a delay of rather less than one second before the relay is de-energised on flame failure.

CONTINUOUS flow balanced hearth walking beam furnaces are the subject of a new brochure issued by The Incandescent Heat Co., Ltd., Smethwick. In this type of furnace, scratching or marking of the work is impossible due to the synchronised motion of the beams as the work traverses the furnace. Costly heat resisting trays can, therefore, be eliminated and the dead load reduced. Temperatures up to 1,200° C. can be successfully used as the beams are built of high quality refractory materials and all moving parts necessary for the motion of the beam are supported on bearings external to the furnace structure. In consequence, maintenance costs are reduced to a minimum.

Books Received

Schleif Industrie Kalendar, 1952. Jubilee Edition. 528 pp. Essen, 1952. Vulkan-Verlag Dr. W. Classen. DM. 14.

"Mazak" 5th Edition. 88 pp. including index. London, 1952. Imperial Smelting Corporation, Ltd. 5s.

"Imperfections in Nearly Perfect Crystals." Symposium held at Pocono Manor, October, 1950. 490 pp. including author and subject indices. New York and London, 1952. John Wiley & Sons, Inc., and Chapman & Hall, Ltd. 60s. net.

"General Metals," by John L. Feirer. 257 pp. including index and numerous illustrations. New York and London, 1952. McGraw-Hill Book Co., Inc. $3 or 25s. 6d.

"Metallurgical Engineering," Vol. 1. "Engineering Principles," by Reinhardt Schuhmann, Jr. 390 pp. including tables and index. Cambridge, Mass. 1952. Addison-Wesley Press, Inc. $7.50.

"The Structure and Properties of Mild Steel," by C. A. Edwards. 222 pp. including indices and numerous illustrations. London, 1952. J. Garnet Miller, Ltd. 20s. net.

LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS

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Modification of the Cambridge Polarograph for Derivative Polarography

By P. R. Pomeroy†, B.Sc., R. A. White† and G. H. R. Gwatkins‡, B.Sc., A.R.I.C.

(*Communication from the British Non-Ferrous Metals Research Association.*)

A low-cost adapter is fitted for this purpose. In addition, a modified electrode is used to reduce the size of the mercury drops to a minimum, thus eliminating the current oscillations.

THE need for rapid methods of analysis for copper-base alloys has led to an enquiry into the possibility of using the polarograph for this purpose. The normal polarographic technique is seldom directly applicable to such alloys, because copper, being a more noble metal than most of the likely minor constituents, causes a wave of such magnitude that the waves due to small amounts of metals depositing at higher potentials are swamped and cannot be isolated. It is, therefore, usually necessary to remove the basis metal by chemical means before proceeding with the determination of the lesser elements, thus losing the advantage of speed. Heyrovsky[1] suggests that this difficulty may be overcome by either of two methods, (*a*) by backing off the polarographic current due to the noble ion by using two solutions with two dropping electrodes and measuring the difference in the current in the two solutions due to the less noble components (differential polarography), or (*b*) by direct determination of the slope of the polarographic curve (derivative polarography).

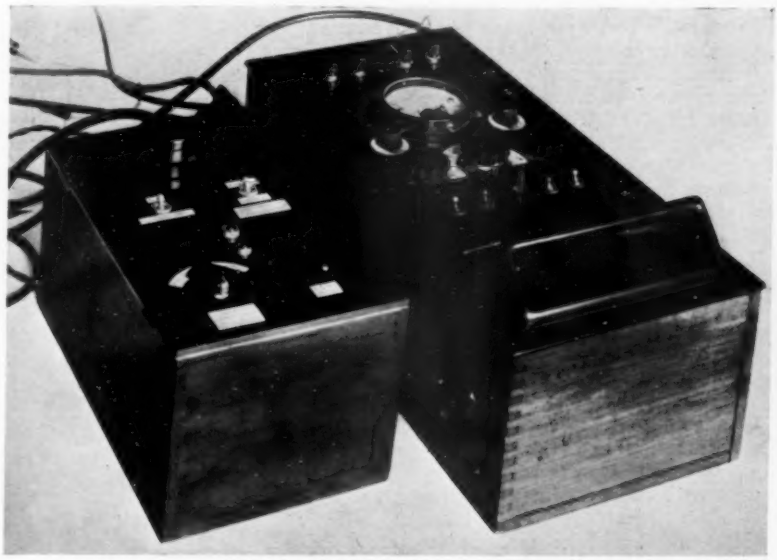


Fig. 1.—Cambridge Polarograph with adapter (left) for derivative work.

In both cases, Heyrovsky suggested methods involving the use of two dropping electrodes of similar characteristics, but as these are difficult to obtain he ultimately used streaming electrodes. Airey and Smales[2] on the other hand used an electro-mechanically synchronised system to control the fall of the drops.

It is clear that the use of one electrode would be simpler and this has been achieved using the derivative method by (*a*) the "A. C. Polarograph" of G. W. Sample[3] in which a small A.C. voltage is superimposed on the D.C. voltage, and the A.C. current measures the slope of the polarisation curve, and (*b*) the technique of Leveque and Roth[4] in which, by connecting a condenser-resistance circuit to the galvanometer of a direct-current polarograph, the galvanometer current is made proportional to the slope of the polarographic curve**.

As Leveque and Roth's procedure appeared to be the simpler, it was examined thoroughly and it was found that a simple adapter (Figs. 1 and 2) could be made which enables the Cambridge Photographic Recording

* British Non-Ferrous Metals Research Association Report R.R.A. 946 P.
† Respectively Investigator and Research Assistant, B.N.F.M.R.A.
‡ Formerly Investigator, B.N.F.M.R.A., now with the National Coal Board.

1 L. Heyrovsky. *Analyst*, **72**, 229 (1947).
2 L. Airey and A. A. Smales. *Analyst*, **75**, 287 (1950).
3 G. W. Sample. Brit. Pat. Spec. 599, 409.
4 M. P. Leveque and F. Roth. *Journ. Chem. Physique*, **46**, 480 (1949).

** An arrangement substantially as described by Leveque and Roth forms the subject of a patent specification (British Pat. Spec. 662,427, application in Great Britain, December, 1949, convention date (Czechoslovakia) January 14th, 1949).

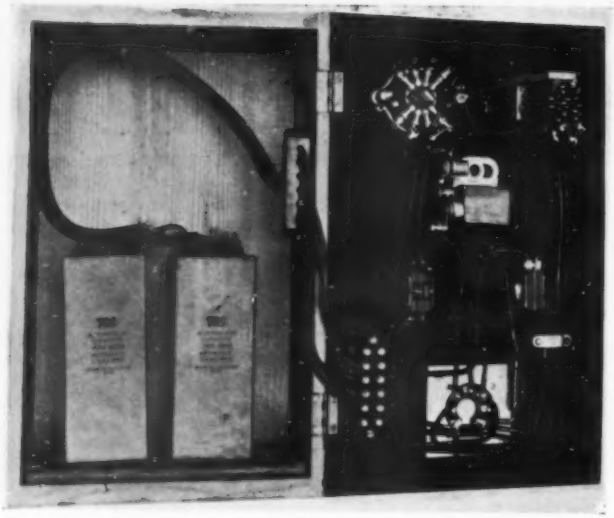


Fig. 2.—Interior view of the adapter.

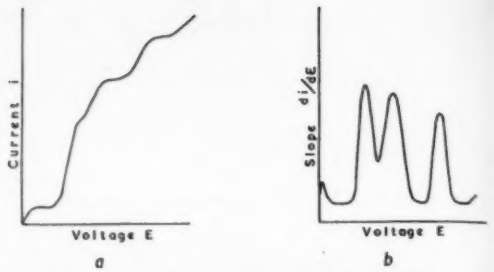


Fig. 3.—(a) Normal direct polarogram ; (b) derivative polarogram of same solution.

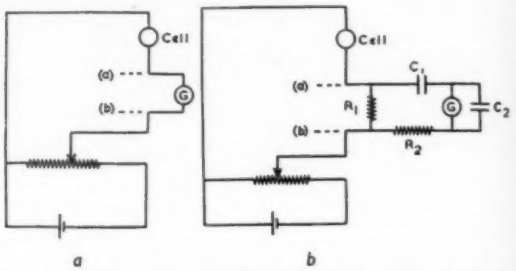


Fig. 4.—(a) Basic circuit of normal polarograph ; (b) basic circuit of derivative polarograph.

Polarograph to be used as a derivative instrument. As a further improvement a novel type of dropping mercury electrode, as suggested by Skobets and Kavetskii for the control and stabilisation of the drop-rate has been adopted. This eliminates the oscillations due to drop formation and thus increases the scope and accuracy of the method.

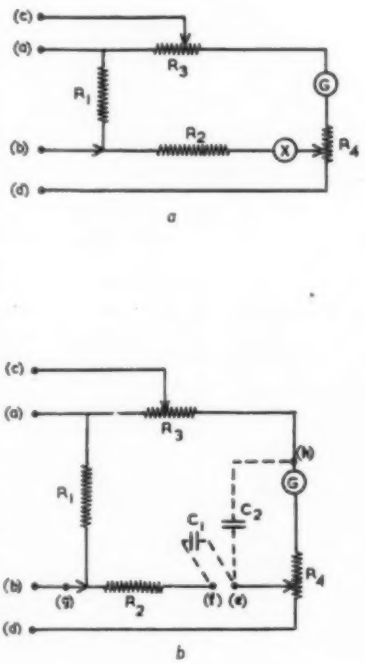
Principle of the Method

If the slope of the direct polarographic curve, Fig. 3a is plotted against the voltage E, a curve of the form of that shown in Fig. 3b is obtained. The "waves" are replaced by "peaks" with maxima at the half wave potential. The height of each peak is substantially independent of peaks occurring at lower potentials. In these circumstances the peak height can be shown to be proportional to concentration[1] and the concentration of an ion can thus be measured independently of the concentrations of other ions. Hence it should be possible to analyse copper-base alloys for minor constituents without prior separation of the copper.

The basic circuit of a normal direct-current polarograph is shown in Fig. 4a with the galvanometer G connected in series with the cell. In the Leveque and Roth circuit, Fig. 4b, the galvanometer is replaced by a resistance R_1, across which is connected the differentiating circuit. This consists of a condenser C_1, a resistance R_2 and the galvanometer G, together with a second condenser C_2, which is connected across the galvanometer. The two condensers have capacities of several thousand microfarads. Thus an electrolytic type must be used and an early difficulty in the practical realisation of the circuit was to find electrolytic condensers with the necessary high stability. Those eventually selected were of the special type specified below and they have proved to be entirely satisfactory in service.

The action of the circuit is briefly described in the following paragraph.

The polarisation current flowing through the resistance R_1 from the polarograph cell creates a voltage drop



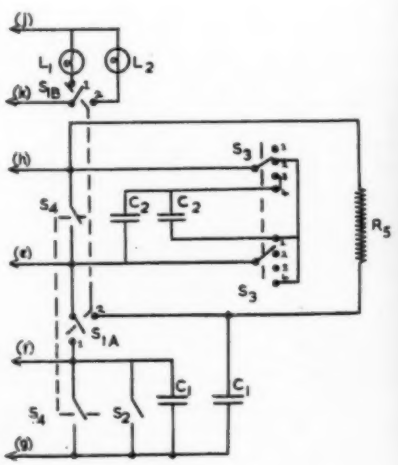


Fig. 5.—(a) Galvanometer circuit of Cambridge Recording Polarograph ; (b) conversion of galvanometer circuit to derivative arrangement ; (c) circuit diagram of adapter unit.

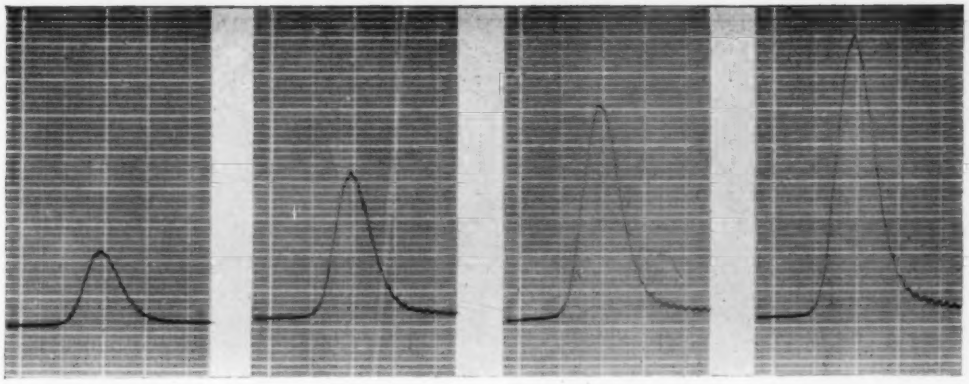


Fig. 6.—Effect of concentration.

2 mg.Cd/100 ml. 4 mg.Cd/100 ml. 6 mg.Cd/100 ml. 8 mg.Cd/100 ml.

Sensitivity : 1/10. Damping condenser : 2,000 microfarad. Differentiating condenser : 2,000 microfarad.
Base solution*: NH_4OH/NH_4Cl—gelatine. Normal electrode.

across R_1 which is proportional to the galvanometer current that is measured in normal direct-current polarography. This voltage drop causes the condenser C_1, to become charged by the passage of current through the resistance R_2 and the galvanometer G.

Leveque and Roth[4] show that by proper choice of values for the components, and provided also that the voltage supplied by the main potentiometer increases at a constant rate, the galvanometer current in the circuit of Fig. 5b is proportional to the rate of change with applied voltage of the galvanometer current in the normal circuit of Fig. 5a. Their circuit thus "differentiates" the normal current-voltage curve, and the derivative curve is obtained from the modified instrument. The condenser C_2 has the important auxiliary function of partially smoothing out the small fluctuations in the galvanometer current caused by the falling drops of mercury. When resistance R_1 is varied and the sum of the values of R_1 and R_2 is kept constant,

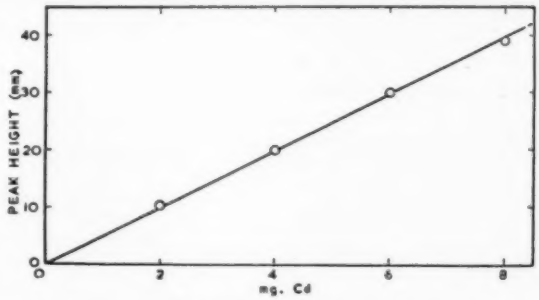
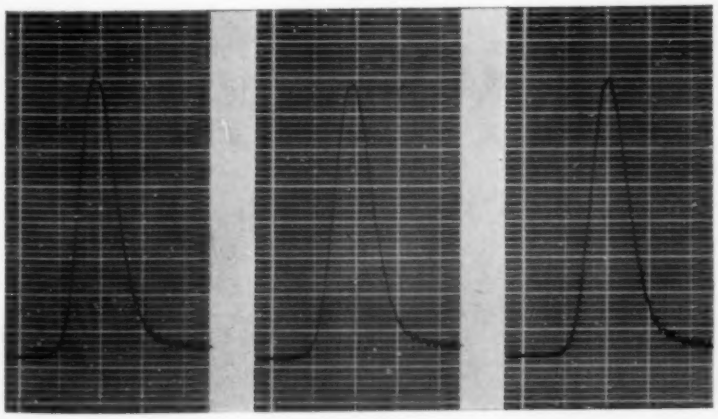


Fig. 7.—Linearity of calibration (see Fig. 6).

the galvanometer deflection remains proportional to the value of R_1. This fact provides one convenient means for adjustment of sensitivity. Alternatively, the sensitivity is proportional within limits to the value of the differentiating condenser C_1.

In the Cambridge Recording Polarograph, the voltage applied from the main potentiometer is arranged to increase linearly with time. This instrument thus requires little modification to convert it to a derivative polarograph of the Leveque and Roth type.

* NH_4OH/NH_4Cl—Gelatine Base Solution : 50 g. ammonium chloride, 25 g. sodium sulphate (crystalline), 80 ml. ammonium hydroxide (s.g., 0·880), 165 ml. water, 5 ml. gelatine solution (1%). This forms half the volume of the final solution.



4 mg.Cd/100 ml. 8 mg.Cd/100 ml. 16 mg.Cd/100 ml.

Sensitivity : 1/5 1/10 1/20
Damping condenser : 2,000 microfarad. Differentiating condenser : 2,000 microfarad.
Base solution : NH_4OH/NH_4Cl—gelatine. Normal electrode.

Fig. 8.—Effect of sensitivity of control setting.

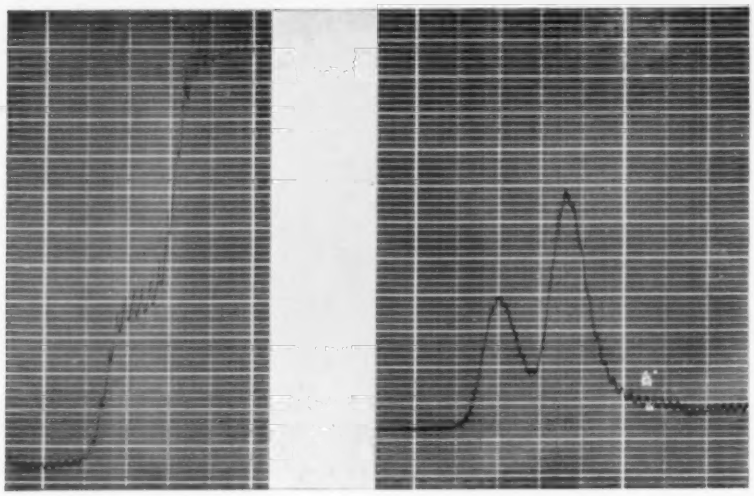
Features of the Derivative Technique

Many experiments have been made with the instrument and the following points, indicating its efficiency and advantages, have been established.

(*a*) *Linearity of the Calibration* (Figs. 6 and 7).—The peak height is proportional to concentration.

(*b*) *Sensitivity Control* (Fig. 8).—The peak height is proportional to the setting of the "sensitivity" control. Thus, the sensitivity scale on the Cambridge Polarograph gives the sensitivity of the derivative polarograph.

(*c*) *Separation of Waves* (Fig. 9).—It is possible to separate and measure peaks if they are 0·1 volt apart. Leveque and Roth claim a separation of 0·06 volt.

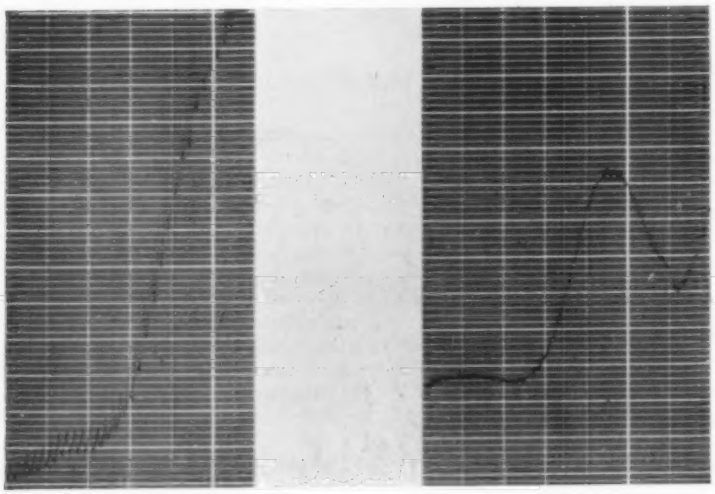


Direct Polarogram. Derivative Polarogram.

4 mg. Cd and 4 mg. Pb in 100 ml. of potassium hydrogen citrate solution.

Direct Polarogram : Sensitivity : 1/10 Derivative Polarogram : Sensitivity 1/5.
Damping condenser : 2,000 microfarad.
Differentiating condenser : 2,000 microfarad.

Fig. 9.—Resolution of close waves.



Direct Polarogram. Derivative Polarogram.

2 mg. Zn in 100 ml. of potassium hydrogen citrate solution.

Direct Polarogram : Sensitivity : 1/5. Derivative Polarogram : Sensitivity : 1/2.
Counter current : 4 units. Damping condenser : 4,000 microfarad.
Differentiating condenser : 2,000 microfarad.

Fig. 10.—Improvement of poorly developed waves.

(*d*) *Improvement of Incompletely Developed Waves* (Fig. 10).—Waves incompletely developed in the direct polarogram can be measured on the derivative polarogram.

(*e*) *Sensitivity* (Fig. 11).—The sensitivity of the derivative instrument (peak height for a given concentration of an ion) is less than that of the direct method (wave height for corresponding concentration). When a normal jet is used the sensitivity is halved and with the dropping electrode of Skobets and Kavetskii (" spade electrode "), a description of which is given later in the paper, the sensitivity is again halved. These decreases in peak height can usually be corrected by increasing the sensitivity of the instrument, thus maintaining the accuracy of measurement.

(*f*) *Effect of Other Ions* (Figs. 12 and 13).—The peak height and accuracy of measurement for a given concentration is substantially independent of the concentrations of ions polarising at lower voltages.

(*g*) *Value of the Differentiating Condenser.*—The peak height is approximately proportional to the value of the differentiating condenser. However, since the condensers are only correct to $\pm$ 20% of their nominal value, switching from 2,000 to 4,000 microfarad does not necessarily exactly double the peak height. The optimum value was found to be 2,000 microfarad but the higher sensitivity given by the 4,000 microfarad setting may sometimes be an advantage.

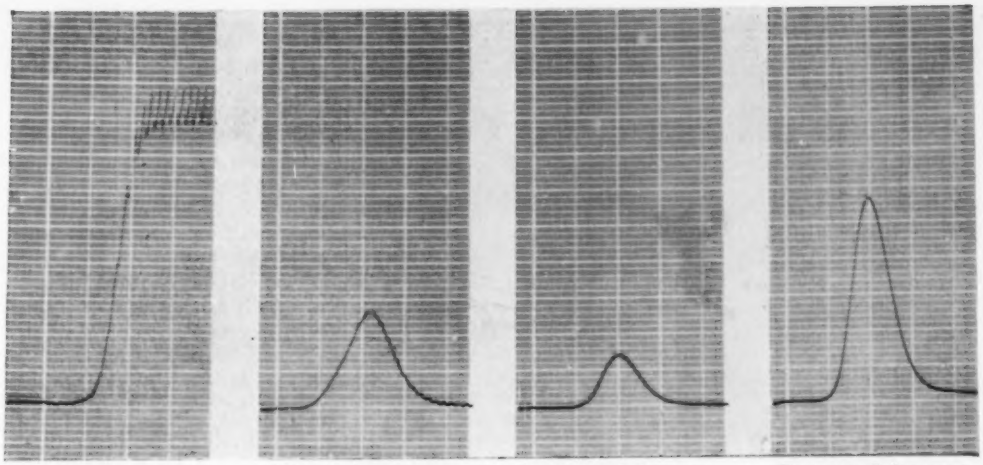
(*h*) *De-aeration.*—It is not generally necessary, though preferable, to de-aerate before analysing. If a peak to be measured occurs at a voltage close to the oxygen peak, de-aeration should always be performed.

(*i*) *Applications.*—The technique can be used with any polarographic method and gives higher accuracy, due to the ease with which the peaks can be measured.

Constructional Details of the Adapter

(*a*) *Circuit.*—While in the basic diagram shown in Fig. 4a the circuit detail between (*a*) and (*b*) is simply a galvanometer, in practice the arrangement is rather more complicated. Fig. 5a shows the galvanometer circuit employed in the Cambridge Photographic Recording Polarograph. Besides being connected at (*a*) and (*b*) into the main circuit, there are auxiliary connections to the main circuit via (*c*) and (*d*). Ignoring these, the general similarity between Fig. 5a and the galvanometer circuit of the derivative polarograph, Fig. 4b will be clear. By breaking the circuit of Fig. 5a at only one point *X*, and inserting the condensers C_1 and C_2 as indicated by the dotted lines in Fig. 5b, the galvanometer circuit of the Cambridge polarograph is converted for derivative polarography. In Fig. 5b, condenser C_1 is the differentiating condenser and C_2 the smoothing condenser.

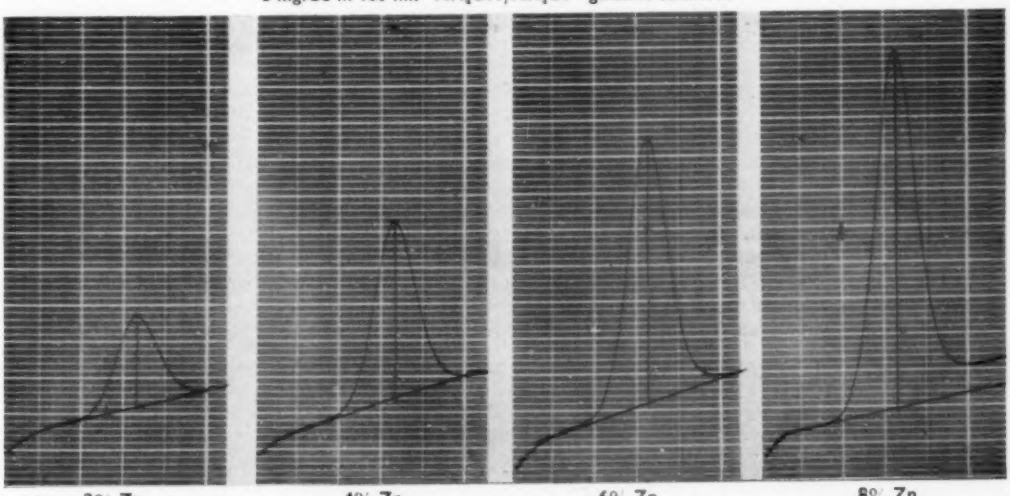
The practical realisation of the adapter circuit is rather more complicated than appears in Fig. 5b because of the need to provide the facility for switching from



Direct Polarogram normal jet	Derivative Polarogram normal jet	Derivative Polarogram "spade" jet	Derivative Polarogram "spade" jet
Sensitivity : 1/20	1/20	1/20	1/5
Damping condenser : —	2,000	2,000	2,000 microfarad
Differentiating condenser : —	2,000	2,000	2,000 microfarad

8 mg.Cd in 100 ml. NH_4OH/NH_4Cl—gelatine solution.

Fig. 11. — **Loss of sensitivity using the derivative technique and the spade electrode.**



2% Zn | 4% Zn | 6% Zn | 8% Zn

Sensitivity : 1/10. Damping condenser : 2,000 microfarad. Differentiating condenser : 2,000 microfarad.
Base solution : NH_4OH/NH_4Cl with 3 times normal gelatine concentration.

Fig. 12. — **Determination of zinc in synthetic copper-zinc alloys. Derivative method with the spade electrode.**

"direct" to "derivative" circuits and to have means for damping the motion of the galvanometer. Accordingly it is necessary to make one further connection, from the adapter to the point (*g*) in Fig. 5b.

It may be noted that in Fig. 5a and b resistances R_1 and R_2 together make up the potentiometer marked "Sensitivity Control" on the Cambridge instrument, resistance R_3 is the "Counter-Current" potentiometer and R_4 the "Cell and Capillary Adjustment," used as a fine sensitivity control.

The first stage in converting the Cambridge Polarograph for derivative work is thus to break the connection to the sliding arm of the "Cell and Capillary Adjustment" control* and to bring connections from the two

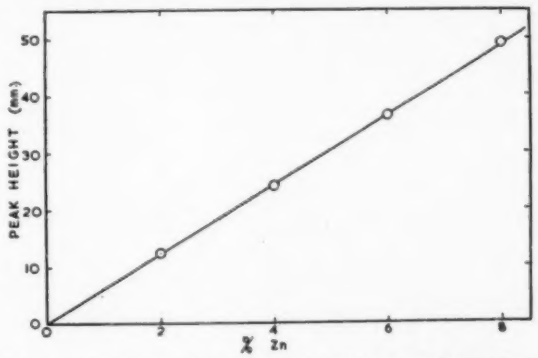


Fig. 13.—Determination of zinc (2–8%) in synthetic copper-zinc alloys. (See Fig. 12).

* Later models of the Cambridge Photographic Recording Polarograph have no "Cell and Capillary adjustment" and when this is the case the circuit is broken at the "Maximum Sensitivity" end of the sensitivity potentiometer.

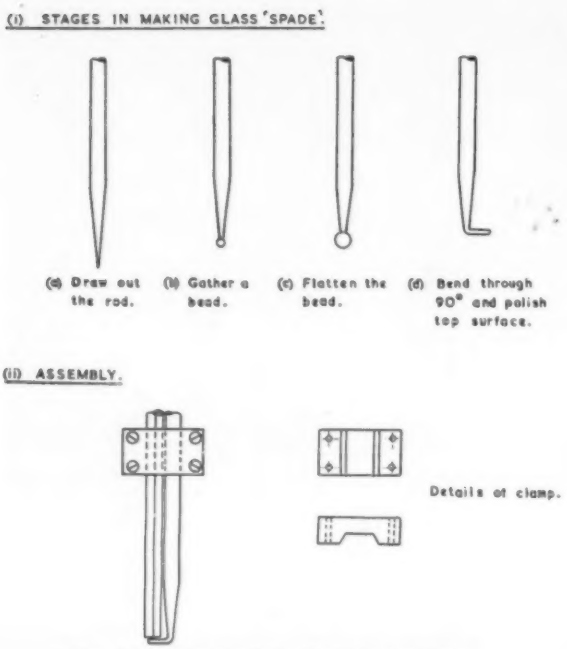

(i) STAGES IN MAKING GLASS 'SPADE'.
(a) Draw out the rod.
(b) Gather a bead.
(c) Flatten the bead.
(d) Bend through 90° and polish top surface.
(ii) ASSEMBLY.
Details of clamp.

Fig. 14.—Construction of spade electrode.

points (*e*) and (*f*) Fig. 5b to the back of the instrument. Connections from point (*g*), Fig. 5b, the "Electrode Negative" terminal which is connected directly to the moving arm of the "Sensitivity" control, and also from point (*h*), that side of the galvanometer connected directly to the "Counter-Current" potentiometer, are also brought out to the back. In addition, two further connections (*j*) and (*k*) are brought to the back direct from the battery to supply a voltage for operating tell-tale lamps in the adapter unit. All six leads are brought into a six-core flexible cable about two feet in length which terminates in a six-point wandering socket. This completes the modifications required for utilising the Cambridge instrument as a derivative polarograph.

The second stage of the conversion is to construct the adapter circuit itself. A circuit diagram is given in Fig. 5c. Connections (*e'*), (*f'*), (*g'*), (*h'*), (*j'*) and (*k'*) are brought out to a six-pin panel-mounted plug to correspond with the connections (*e*), (*f*), (*g*), (*h*), (*j*) and (*k*) on the polarograph itself.

The adapter unit has four control switches the functions of which are described below with reference to Fig. 5c :—

S_1.—This is a double-pole change-over switch in which S_{1A} effects the change from "Direct" (position 1) to "Derivative" (position 2) setting, whilst S_{1B} operates the tell-tale lamps.

S_2.—This is an on-off switch ; in the open position the "Differentiating Condenser" has a capacity of 2,000 microfarad and in the closed position 4,000 microfarad.

S_3.—This is a double-pole four-way switch which is effective in both "Direct" and "Derivative" settings. The "Damping Condenser" values are : position 1—open circuit ; position 2—capacity 2,000 microfarads ; position 3—capacity, 4,000 microfarads ; position 4—capacity, 8,000 microfarads.

S_4.—This is a double-pole on-off key which controls the "Galvanometer Damping." It is effective on both "Direct" and "Derivative" settings. When closed, the galvanometer is damped but the switch springs back to the open circuit position when released.

When switched to permit derivative polarography, the "Cell and Capillary Adjustment" control on the polarograph should be set to zero. In the "Derivative" position the "Galvanometer Zero Adjustment" control on the polarograph is operative. The "Counter Current" control may also be used for zero adjustment. The calibration of the stepped "Sensitivity" control applies equally to the "Direct" and "Derivative" settings.

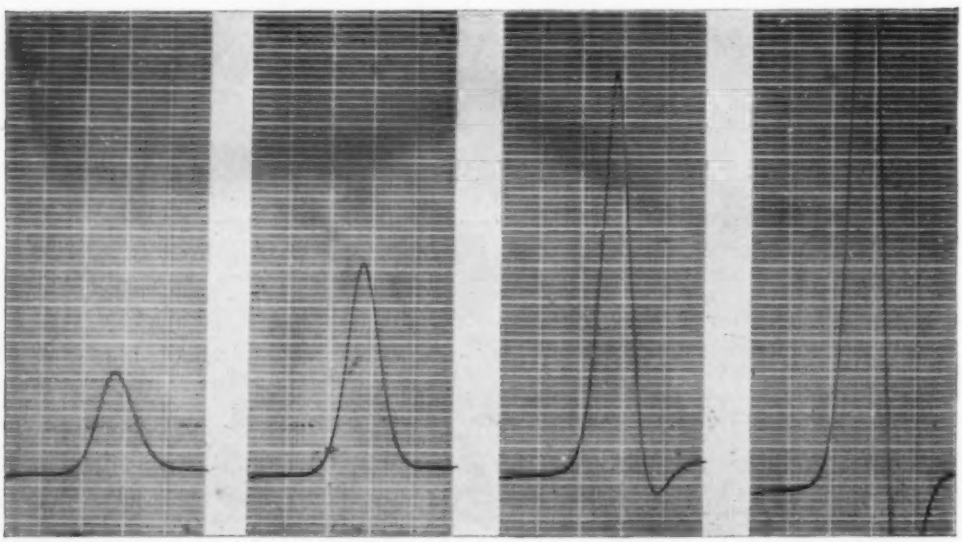

4 mg.Zn/100 ml.
8 mg.Zn/100 ml.
12 mg.Zn/100 ml.
16 mg.Zn/100 ml.
In the presence of 10 mg. Cu. base solution, NH_4OH/NH_4Cl with normal gelatine concentration.
Sensitivity : 1/10. Damping condenser : 2,000 microfarad. Differentiating condenser : 2000 microfarad.

Fig. 15.—Effect of spade electrode on the optimum concentration of maximum suppressor.

Two values of differentiating condenser are provided according to the position of Switch S_2, "Differentiating Condenser." In preliminary work it was found that a capacity of 2,000 microfarad was most useful but since it was possible to obtain only 4,000 microfarad condensers, and it was thought that an available capacity of 4,000 microfarad might sometimes be required, it was decided to provide means of switching from 2,000 to 4,000 microfarad. Similarly, with the "Damping Condenser" controlled by S_3, capacities of 2,000, 4,000, and also in this case 8,000 microfarad are available.

The damping condensers are in circuit in both "Direct" and "Derivative" settings, but the resistance R_3 in Fig. 5c, the value of which is chosen to produce critical damping of the galvanometer, is in circuit only in the "Derivative" setting.

The spring-return "Galvanometer Damping" key, S_4, when depressed, short-circuits the galvanometer and also short-circuits the charging resistance R_2, thus enabling the differentiating condenser, C_1, to become charged rapidly when damping is applied.

(*b*) *Construction.*—The layout of the adapter is shown in the photographs, Figs. 1 and 2. The four condensers comprising C_1 and C_2 are mounted on a separate panel which slides between stops into the base of the container. Leads run from this to a terminal block on the bakelite panel. The rest of the wiring including the two tell-tale lamps is mounted on this panel as shown.

(*c*) *Components.*—The components used in the construction of the adapter are as follows :—

4 4,000 microfarad electrolytic condensers (T.C.C. 1-volt D.C. working non-polarised instrument condensers are suitable. The usual 2,000 microfarad 12-volt D.C. working condensers are not satisfactory owing to their large and variable leakage resistance.)
1 Single-pole single-throw toggle switch.
1 Double-pole double-throw toggle switch.
1 2-pole 4-way wafer-type switch.
1 Double-pole single-throw key.
2 4·5-volt pea lamps.
2 Panel type lamp holders.
1 2,000 ohm ½-watt wire wound resistance.
2 6-way terminal blocks.

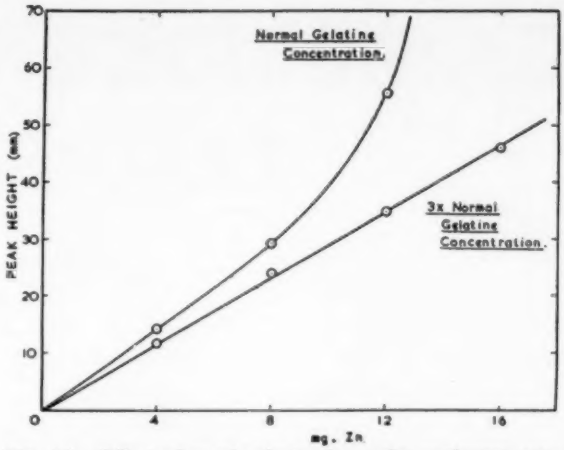


Fig. 16.—Effect of spade electrode on the optimum concentration of maximum suppressor (from Figs. 15 and 17).

1 6-way "Belling Lee" panel-mounting plug and wandering socket.
1 Length 6-core cable.

Operation of the Instrument

Whilst by no means a complete account of the operation of the modified polarograph, some of the more important points and precautions are given in the following paragraphs.

(*a*) *General Case.*—With the solution to be analysed in the cell, the voltage on the dial is set to about 0·25 volt below the half-wave potential of the ion being determined and the adapter switched to "Derivative."

As the condensers become charged the galvanometer gives a large deflection, which slowly diminishes until an almost steady reading is reached. The reading is seldom perfectly steady: owing to drop formation it usually oscillates about a mean position.

Stabilisation can be hastened by operating the "Galvanometer Damping" Key.

When the galvanometer is steady with the damping key open the zero is adjusted to a suitable value and the motor is started. The galvanometer deflection increases

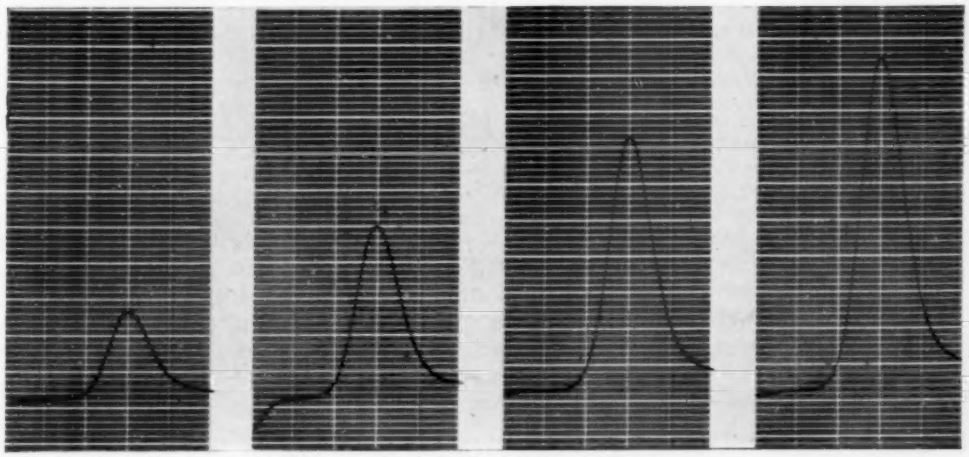


Fig. 17.—Effect of spade electrode on the optimum concentration of maximum suppressor.

Concentration and conditions as in Fig. 15, but with a threefold increase of the gelatine concentration.

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at first, and if no ions are present becomes steady. If ions are present, a sharp peak occurs, the current falling again to a new base line. The peak height from the first base line is proportional to the ionic concentration. For rapid routine work the peak height can be read directly without having to photograph the trace. If the trace is recorded, it is not usually necessary to construct lines on the graph to determine the peak height.

(*b*) *Operation when a Large Concentration of an Ion Polarising at a Low Voltage* (*e.g. Copper*) *is Present.*—When a large concentration of an ion polarising at a low voltage is present, a large peak may be formed at its polarising voltage. This is so in the analysis of copper-base alloys and if the sensitivity is high enough to measure minor constituents (for example 1% zinc) the peak current due to the deposition of the copper may be great enough to damage the galvanometer. The decay of the large peak current does not correspond in these circumstances to the slope of the polarographic curve after the copper peak. At the normal rate of voltage increase (0·1 volt in 20 seconds) the decay of the copper peak is not complete until 1 volt is reached, and ions polarising at less than 1 volt cannot therefore be detected. This difficulty is best overcome by running the polarograph to just above the copper deposition voltage and allowing the instrument to stabilise at this voltage with the "Galvanometer Damping" key depressed. The time required is 30 seconds to 1 minute.

After the instrument is stabilised, the zero is adjusted and the motor drive to the potentiometer switched on. The minor constituents can then be measured as if the copper were not present.

However, if a normal single dropping mercury electrode is used, the oscillations due to the falling drop are large compared with the peak height and the accuracy is reduced. A means of overcoming this difficulty is described below.

(*c*) *Use of Alternative Forms of Dropping Electrode.*—The accuracy of any polarographic measurement is reduced by the presence of current oscillations due to the falling drops. In derivative polarography this often makes the evaluation of a small peak following a large one very difficult. Fortunately it was found possible to eliminate these oscillations by the use of alternative designs of dropping electrodes.

The use of multiple jets as described by Payne[5] greatly decreases the oscillations, but is not recommended except where the greatest sensitivity is essential because of the necessity of keeping the six jets clear.

Another satisfactory design of jet depends on the fact that the magnitude of the oscillations is decreased by reducing to a minimum the ratio of the surface area of the drop immediately before separation to that of the mercury left at the surface of the jet after separation. This value is particularly low with the "Spade" jet[6], in which it is achieved by placing a glass spade directly underneath the jet orifice. With this electrode the oscillations are negligible even with a solution of 1% zinc in copper, though the sensitivity is only about half that obtained when a normal jet is used.

The method of constructing the jet is shown in Fig. 14. A piece of glass rod is flattened, bent through 90° and the top surface of the spade polished. The spade is adjusted until it is just clear of the end of the capillary, so that small drops fall at a rate of about 10 per second, and it is then clamped in position, by two small bakelite clamps. The spacing between the jet and the spade is fairly critical and is best adjusted by trial and error. Once set the spacing must not be allowed to change.

It was found that spurious results were obtained when the modified electrode was used with the normal amount of maximum suppressor in the presence of high concentrations of reducible ions. Figs. 15 and 16 show an example of this. The height of each peak is not proportional to the concentration of reducible ion (Fig. 16) and the effect of maximum formation is clearly shown by the overshooting of the curve after the peak (Fig. 15) The appearance of the overshoot is an indication that insufficient maximum suppressor has been used; addition of more remedies this fault (Figs. 16 and 17). The effect is believed to be due to the fact that the efficiency of the maximum suppressor is less at the beginning of the life of a drop. Since the "spade" electrode prevents the drop from developing to the normal size a larger amount of maximum suppressor is required.

(*d*) *Precautions.*

(i) Since the operation of the differentiating circuit requires the rate of change of the applied voltage with time to be constant, the potentiometer must run without stopping from at least 0·2 volt below, to 0·2 volt above, the half-wave potential of a particular ion to ensure that the concentration is accurately measured.

(ii) The galvanometer must be steady before starting to record.

(iii) To avoid damaging the galvanometer and to decrease the time for stabilisation, particularly when it is intended to measure peaks occurring after a large peak, damp the galvanometer when it is passing through the large peak.

Summary and Conclusions

An adapter to the Cambridge Polarograph is described which enables the instrument to be used either as a derivative instrument, as suggested by Leveque and Roth, or as a normal direct polarograph.

The adapter, which is inexpensive, is capable of determining the concentration of minor components which polarise after the main constituents. Other advantages are separation of close waves, measurement of poorly developed waves, and that de-aeration is normally unnecessary. The oscillations due to the drops which so often reduced the accuracy of polarographic methods are removed by the use of an alternative form of electrode. The adapted polarograph should be of value for the rapid analysis of copper-base alloys.

Acknowledgments

The thanks of the authors are due to the Director and Council of the British Non-Ferrous Metals Research Association for permission to publish this paper and to Mr. S. Velken (Stavanger Electro-Staalwerk A/S, Stavanger, Norway) who did a large proportion of the initial testing of the instrument, and suggested the use of the "Spade" electrode.

5 S. T. Payne. *Anal. Chim. Acta*, **3**, 86 (1949). (B.N.F. Technical Memorandum No. 61.)
6 Skobets and Kavetskii. *Zavodskaya Lab.*, **15**, 1299 (1949).

Hungarian Bauxite Mining Increase

HUNGARIAN sources announce that the production of aluminium ingots in Hungary during 1951 was 20 times as great as in 1938. That year 549,000 tons of bauxite was extracted, of which only 6% was processed at home : the rest was exported, mainly to Germany, most Hungarian mines being German owned. Hungarian bauxite deposits are estimated at 300 million tons by the experts, or one-tenth of world deposits, and 60% of European deposits. Extraction of ore, which is considerably higher than in 1938, is to be increased by over half during 1952. Half the ore is now processed in Hungary, where aluminium is used for a number of new purposes, such as bridge-building, and scaffolding. A new processing plant was opened at Almasfuzito early in 1951, and another new plant is scheduled for construction at Inota, where a big electric generating station began operation last autumn.

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Correction

SCIENTIFIC INSTRUMENT EXHIBITIONS

WE regret that in the notice of the forthcoming series of exhibitions of scientific instruments and laboratory equipment organised by Standley, Belcher and Mason, Ltd., we inadvertently stated, on page 102 of our August issue, that the venue for the Birmingham exhibition, to be held on October 28th, 29th and 30th, would be the Grand Hotel. Arrangements have, in fact, been made for it to be held at the Midland Hotel.

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